NATIONAL OCEANIC and ATMOSPHERIC ADMINISTRATION

Baseline Polar-orbiting Operational Environmental Satellite Command and Data Acquisition (CDA) And Satellite Operations Control Center (SOCC) Equipment Configuration

30 November 1999

Signature Page

Baseline Polar-orbiting Operational Environmental Satellite Command and Data Acquisition (CDA) And Satellite Operations Control Center (SOCC) Equipment Configuration

This document reflects the requirements for the Polar-orbiting Operational Environmental Satellite (POES) system for participation in the Initial Joint Polar Satellite System to be implemented in the 2003 time period.

For NOAA

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1 Introduction

The United States has conducted meteorological data collection from space since the successful launch of the Television Infrared Observation Satellite (TIROS) on 1 April 1960. It has maintained a polar orbiting environmental satellite system in continuous operation from the first launch until the present time. Today's version of satellites are known as the Polar-orbiting Operational Environmental Satellite (POES) series. Environmental data is collected and distributed to the U.S National Weather Service, other Government agencies, researchers, and other meteorological data users. The environmental data is provided as input to weather forecasting, severe storm detection and tracking, wind measurements, sea surface thermal conditions, frost, sea surface ice conditions, and precipitation estimate models.

1.1 Purpose

The purpose of this document is to provide an overview of the basic elements of the current POES ground command, control, and data acquisition equipment. It provides a level of detail sufficient to introduce the Command and Data Acquisition (CDA) and Satellite Operations Control Center (SOCC) ground equipment of the polar satellite system and the manner in which the system is configured.

1.2 Background

The National Environmental Satellite, Data, and Information Service (NESDIS) of National Oceanographic and Atmosphere Administration (NOAA) is responsible for operating the U.S. environmental satellite programs. As part of this responsibility, NESDIS manages the NOAA polar orbiting satellite system. This responsibility includes the command and control of satellites, satellite meteorological data acquisition, processing of meteorological and other environmental data, product distribution, and data storage. NESDIS supports these responsibilities through the capabilities of the polar satellite ground system. The ground system is comprised of the SOCC and Central Environmental Satellite Computer Center (CEMSCS) located in Suitland, Maryland, and the NOAA CDA stations at Fairbanks, Alaska and Wallops, Virginia.

2 SOCC and CDA Overview

Commanding of the POES satellites is conducted from the SOCC, through communications links with the ground system facilities at the CDA stations. State of health and environmental data are routed to the SOCC and CEMSCS via communications links. Commanding and data acquisition are performed when the orbiting satellites are within line of sight of the CDA station's command transmitting and data receiving antennas. The linkages between polar ground segment facilities are illustrated in Figure 2.0-1. Polar orbiting satellite operations are conducted using the Polar Acquisition and Control Subsystem (PACS). PACS is a computer based real-time command and control system. Satellite operators conduct commanding and data acquisition by using an automated schedule running on PACS. The capability for operator manual intervention exists and is used when circumstances dictate. Part of the schedule driven system is the Command Level Schedule. It is used to configure the CDA and SOCC ground equipment in consonance with spacecraft activities.

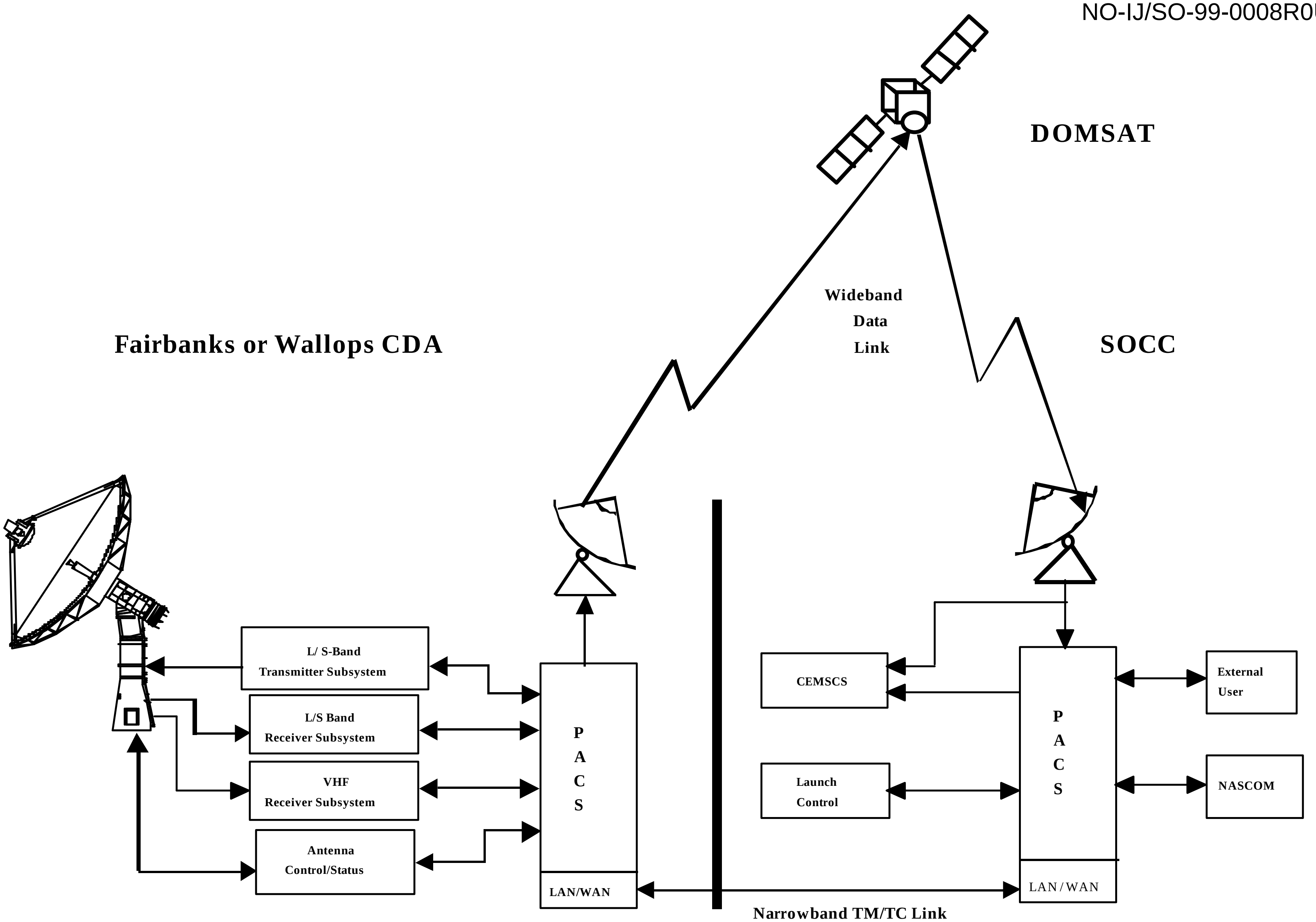

Figure 2.0-1 SOCC/CDA Overview

Collection of satellite instrument data and transmission (downlink) to ground facilities is under the control of the satellite Stored Command Table (SCT). The SCT load is generated at SOCC to meet users requirements using the Satellite Operations Management Subsystem (SOMS). It is transmitted and loaded into the on-board redundant Central Processing Unit's (CPU) memory of each operational satellite daily. Standby and non-operational satellites receive less frequent uploads.

PACS performs the processing and display of spacecraft health and safety telemetry for operator monitoring, and generates commands for control of spacecraft subsystems and ground equipment. Analysis software tools are provided for off-line engineering support. A non-real-time function performed outside of PACS is schedule generation. SOMS generates the schedules that run on PACS and in the SCT. Generation of the schedules is performed in non-real-time to produce time tagged events for automated operation of spacecraft subsystems and ground system equipment.

2.1 Reference Documents

1. Overview NOAA-Polar Satellite System, September 1994
2. NOAA_KLM POES Ground System Block Diagram, November 1998
3. NPAS FCDAS and WCDAS FOC System Design Review, November 1998
4. Datron Transco Inc / Operations and Maintenance Manual for the 13-meter Telemetry and Command Remote Satellite Sensing Antenna System / M-012279, May 1998
5. Integral Systems Inc / EPOCH 2000 Fairbanks LEO-T Operations and Maintenance Manual / ISI-LEO-T-0002, January 1999
6. AlliedSignal Technical Services Corporation/ Operations and Maintenance Manual for the 13 meter Tracking Antenna Systems, November 1998

3 CDA Station Description

The CDA station's primary mission is to meet the command, telemetry, data transmission and data acquisition requirements of the current fleet of polar-orbiting and geostationary satellites managed and operated by NOAA. Today's fleet consists of satellites from the POES program, Geostationary Operational Environmental Satellite (GOES) program, and the Defense Meteorological Satellite Program (DMSP).

The Fairbanks CDA consists of three 13-meter antennas with L/S-Band simultaneous transmit/receive capability. A separate VHF receive only antenna is slaved to any one of the 13-meter antennas.

The Wallops CDA consists of two 13-meter antennas and a 14.2-meter andtenna all with L/S-Band simultaneous transmit/receive capability. Additionally the 14.2-meter antenna is capable of receiving VHF frequencies. Back-up S-Band transmit capability for the 14.2-meter antenna is provided by a slaved 4-meter antenna.

The following sections describe the common CDA functions as they relate to the POES program. Specific differences between the Fairbanks and Wallops CDAs are also described.

3.1 Data Acquisition Subsystems

3.1.1 13-Meter Antennas

The 13-meter reflector is mounted on a three axis pedestal capable of 15 degrees per second azimuth and 7.5 degrees per second elevation travel. To extend servo life, the azimuth drive is limited to 12 degrees per second by the control software. All interfaces between the control room and the antennas are through fiber optic cable.

Each antenna system is capable of receiving L-Band (1.67-1.71 GHz), S-Band (2.2-2.4 GHz) and X-band (7.0-9.0 GHz) Radio Frequency (RF) signals, and transmitting at L-Band (1.75-1.85 GHz) or S-Band (2.0-2.12 GHz). The received RF signals are focused by the parabolic reflector onto a frequency selective dichroic sub-reflector. The L and S-Band RF signals pass through the sub-reflector to the L, S-Band feed mounted at the prime focus position. The dichroic sub-reflector also focuses the X-Band RF energy on a vertex mounted X-Band feed. Both feeds provide auto-tracking capability, although X-Band auto-tracking has not been fully implemented at this time.

3.1.1.1 Antenna Control

The antenna system's auto-track capability is provided through the use of a Tunable Universal Track Receiver (TUTR). Refer to Figure 3.1.1.1-1. The TUTR is a pseudo-monopluse track receiver capable of providing auto-track signals for receive frequencies up to 3 GHz. Each TUTR is capable of providing auto-track signals for L-Band, S-Band, or X-Band receive frequencies. Two TUTRs are currently installed and connected to the L/S-Band feed to provide auto-track for left and right-hand circular polarized signals. The X-Band feed does have an output that is downconverted to S-Band by the block converter located in the pedestal and supplied to a patch panel at the TUTR location. However, no TUTR is connected to the downconverted output. The TUTRs provide an Automatic Gain Control (AGC) voltage output signal that is routed to the Digital Electronics Unit (DEU). The DEU is capable of receiving an input from three TUTRs. When the DEU is in Auto-Acquire mode, the DEU monitors each TUTR's AGC and switches from program track to auto-track mode when either or both AGCs go above a pre-set threshold. The DEU can automatically switch from auto-tracking the L/S -Band frequency to auto-tracking the X-Band frequency and returning to the L/S-Band frequency. The DEU returns to program track if all AGC signals fall below the pre-set threshold.

The 13-meter antenna systems are configured and controlled via EPOCH 2000 LEO-T software. Refer to Figure 3.1.1.1-2. Each antenna system is supported by an individual LEO-T workstation. However, any one of the LEO-T workstations can support all three of the 13-meter antennas. The LEO-T workstations are connected to the Front End Processor (FEP) via a Local Area Network (LAN). The FEP is a VME RISC system running Real-time UNIX. The FEP provides RS-232 interfaces for control/status to and from the following devices: Bit Synchronizers, Receiver/Combiner Pair, Exciter, DEU and the Intelligent Multiplexer (IMUX) Recorder.

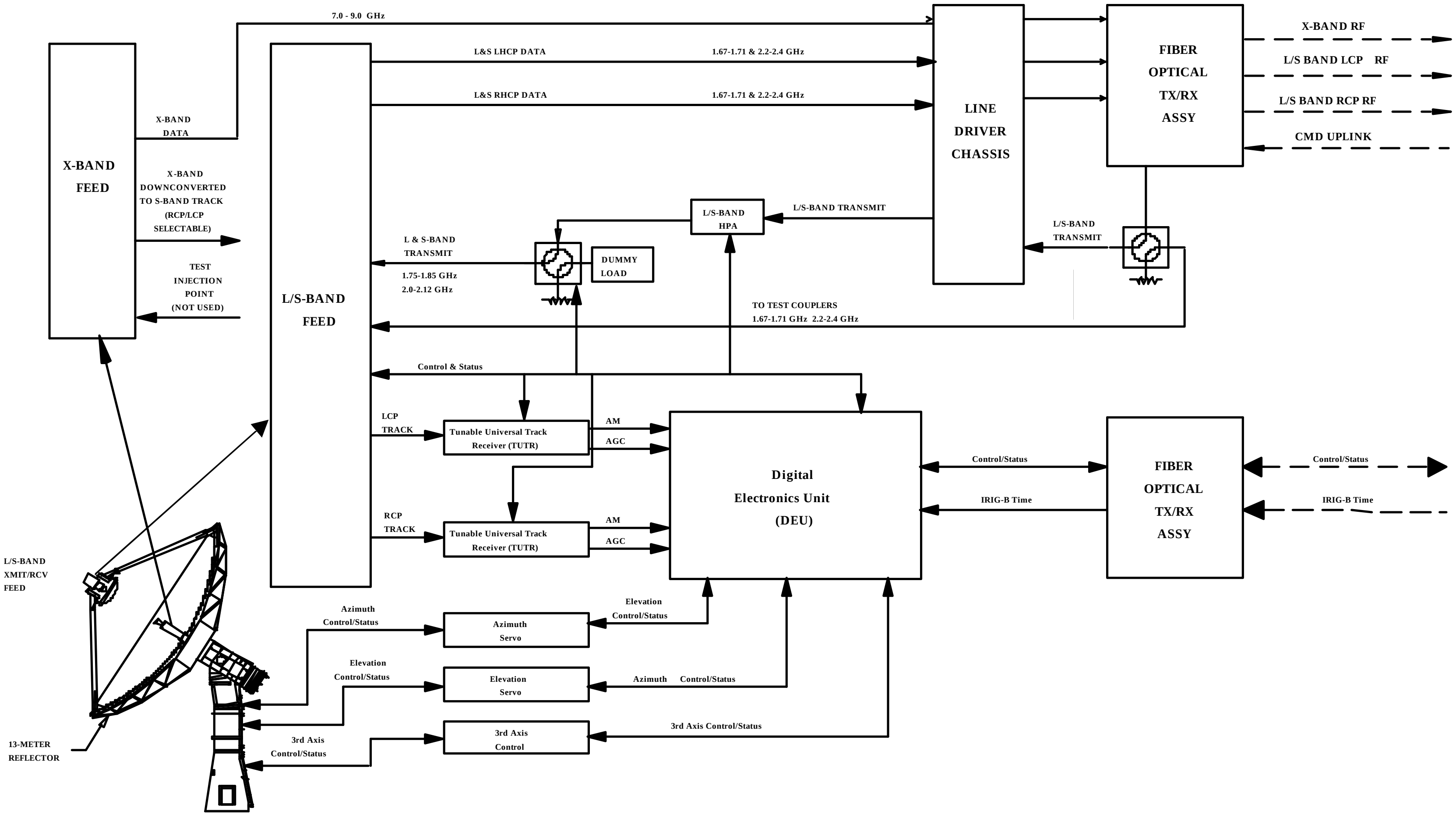

Figure 3.1.1.1-1 13-Meter Antenna

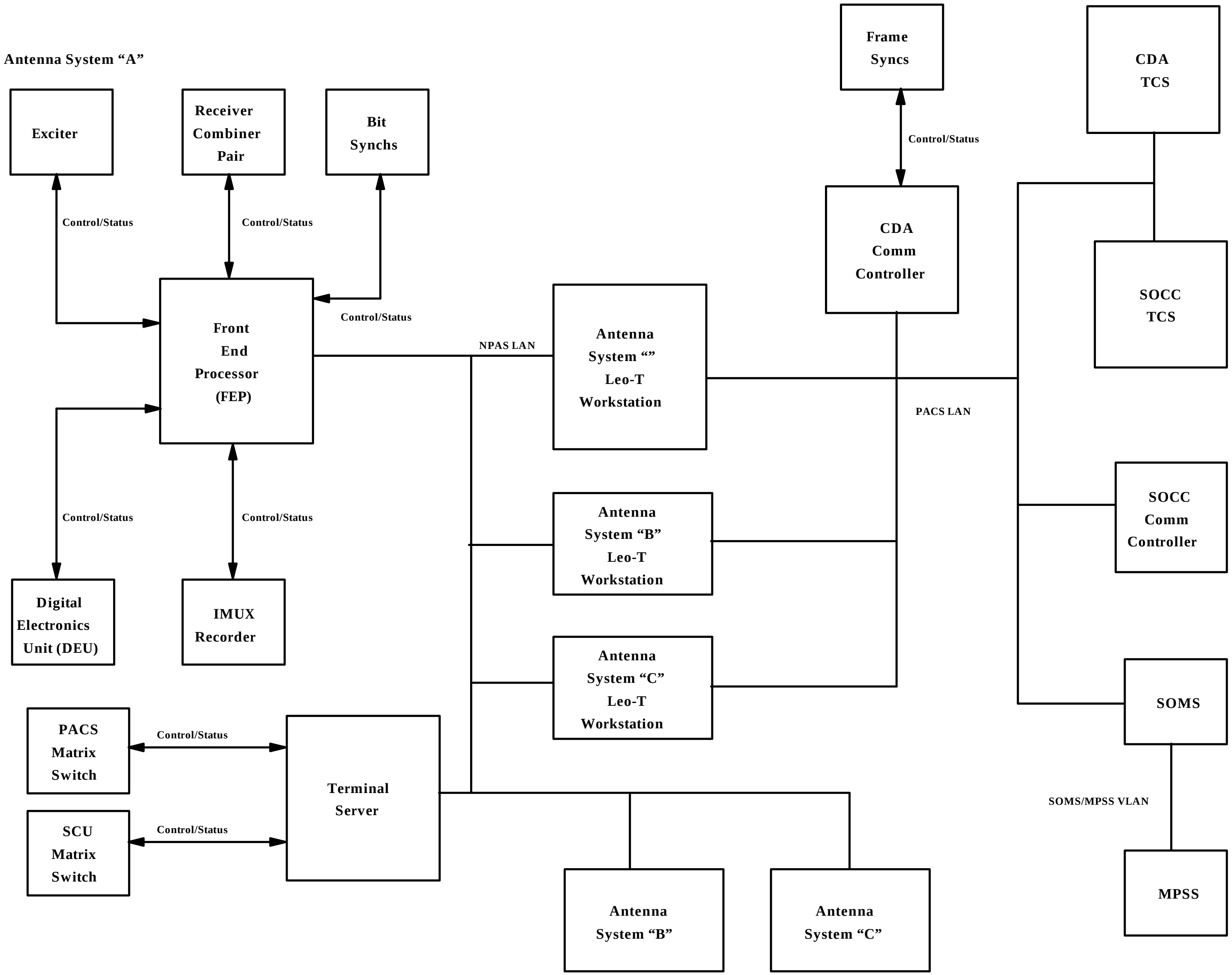

Figure 3.1.1.1-2 CDA PACS Equipment Control/Status

3.1.1.2 Downlink Data

The L/S-Band feed operates with both Left-hand Circular Polarization (LCP) and Right-hand Circular Polarization (RCP) signals simultaneously. The X-Band feed operates at one, selectable polarization setting at a time. Refer to Figure 3.1.1.1-1 and 3.1.1.2-1. The L/S-Band RCP, L/S-Band LCP and X-Band downconverted to S-Band signals are routed to three fiber optic links and transmitted to the Operations building. The output of the L/S-Band fiber optic links within the Operations Building are fed to multicouplers which feed multiple data receiver pairs. One of the receivers in the pair processes the RCP component of the downlink, the other processes the LCP component. The IF outputs of the receiver pair are then combined and demodulated by the associated diversity combiner. The demodulated data output from the diversity combiner is then sent to a bit synchronizer. Each 13 meter antenna system has five strings with each string consisting of a LCP and RCP receiver pair, a diversity combiner and a bit synchronizer. The X-Band fiber optic data is currently not processed any further.

The 13-meter antenna systems support a variety of data rates, with the maximum data rate currently supported being 2.662 Mbps. The bit synchronizers are capable of supporting data rates up to 5 Mbps, although receiver IF bandwidths limit the maximum ingest data rate to approximately 3 Mbps Bi-phase codes or 4 Mbps NRZ codes. Each bit synchronizer is capable of providing a times 1, times 2, or times 4 clock for any input data rate. For example: 1.33 Mbps output for 1.33 Mbps, 665 Kbps, or 332.5 Kbps input. The bit synchronizers' data and clock outputs are sent to a PACS Matrix Switch, an IMUX Recorder and a System Communications Unit (SCU) Matrix Switch.

The IMUX recorder on each antenna system receives data from all five of that antenna's bit synchronizers. Refer to Figure 3.1.1-3. The data is multiplexed into a single data stream for recording. The IMUX is capable of supporting up to 60 channels of input data with a combined input data rate of 96 Mbps. Each individual input channel is capable of supporting a data rate of 20 Mbps. The IMUXs installed at the CDAs have a 7 channel input/output capability however, only 5 channels are integrated. The combined input channels of the IMUX are multiplexed into a single data stream that is simultaneously recorded on a 9 Gbyte hard drive and a digital tape recorder for playback and data archiving. The digital tape recorder contains nine (9) tape cassettes each capable or storing 42 Gbytes. If a playback of data that is only on the tape is required, the data is first transferred to the disk drive and then output. The outputs of the IMUX recorder are supplied to the bit synchronizers. Playback data is then routed from selected bit synchronizers to the PACS Matrix Switch or the SCU Matrix Switch.

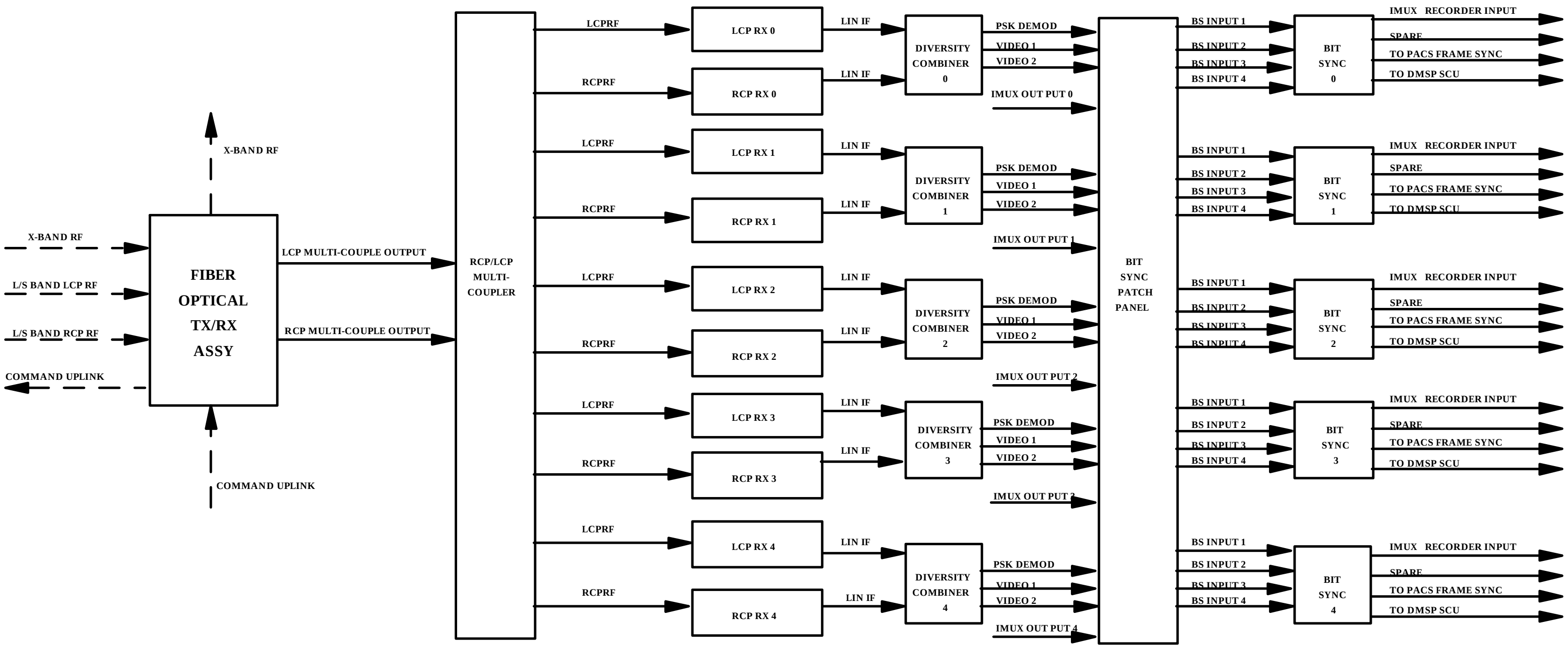

Figure 3.1.1.2-1 13 Meter Antenna RF Processing

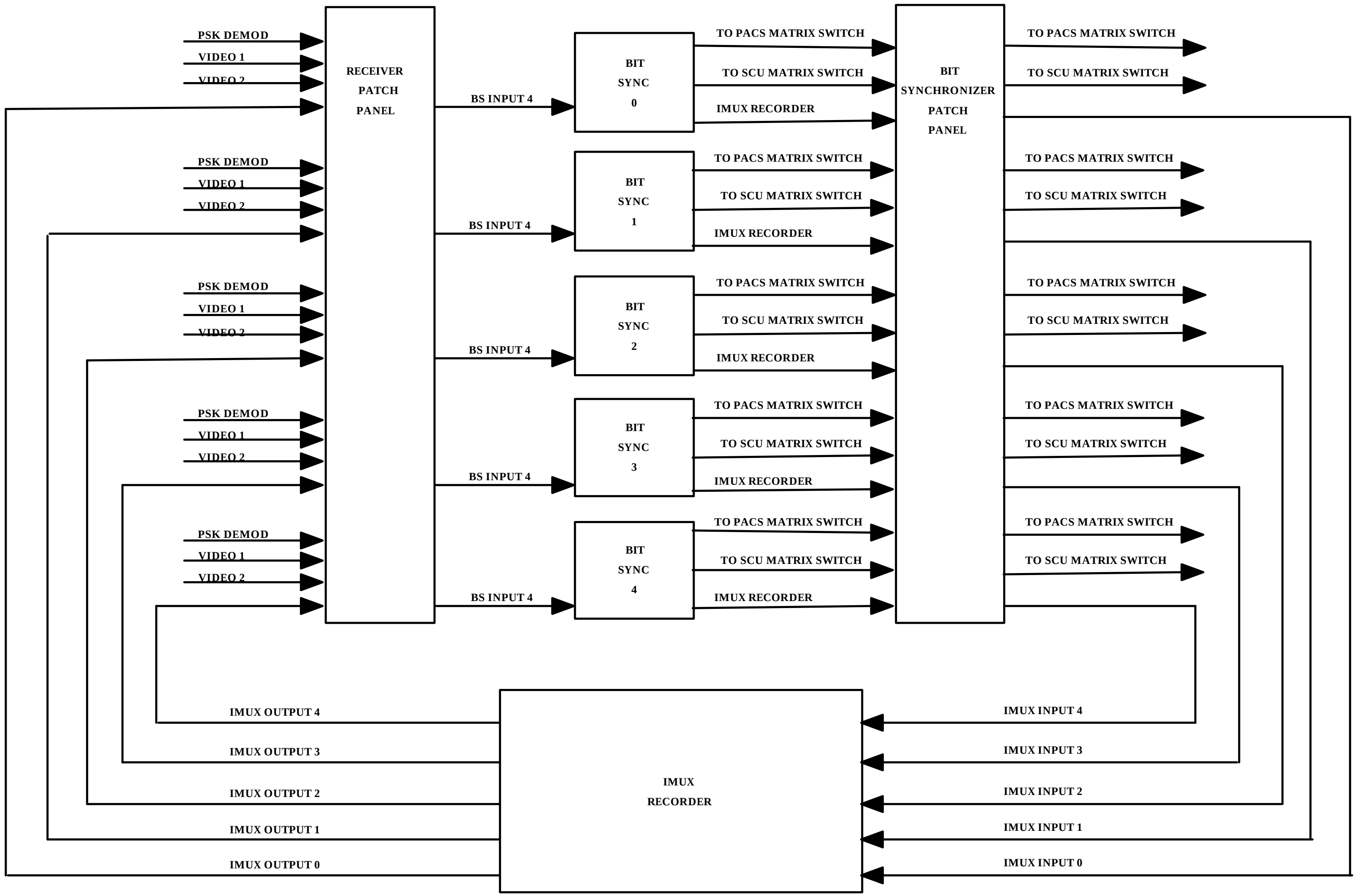

Figure 3.1.1.2-2 IMUX RECORDER

3.1.1.3 Command Uplink

The 13-meter antennas support both L-Band (DMSP) and S-Band (POES) commanding. PACS uplink for NOAA-K, L, M, N and N' series satellites is Unified S-Band format while DMSP's format is Space-Ground Link Subsystem (SGLS). Refer to Figures 3.1.1.1-1 and 3.1.1.3-1. The PACS Unified S-Band commands are modulated on a 16 kHz subcarrier by redundant command generators and sent to the 13 meter antenna system. The SGLS commands are received as four separate data lines and are then processed by the FEP of each 13-meter system and Frequency Shift Key (FSK) modulated. The uplink command matrix switch routes either the PACS or SGLS command stream as the command source to the exciter. The command matrix switch has four inputs: one for PACS Command Generator 1, one for PACS Command Generator 2, one for SGLS commands, and an input for simulated telemetry. The exciter modulates the uplink RF carrier with the selected command source. The resulting RF signal is then sent to the antenna via a fiber optic link. The output of the fiber link is sent to a high power amplifier (300 Watt maximum) which is then coupled to the L and S-Band feed for transmission to the spacecraft. The exciter is also used to inject simulated telemetry or bit error rate data through the antenna front end.

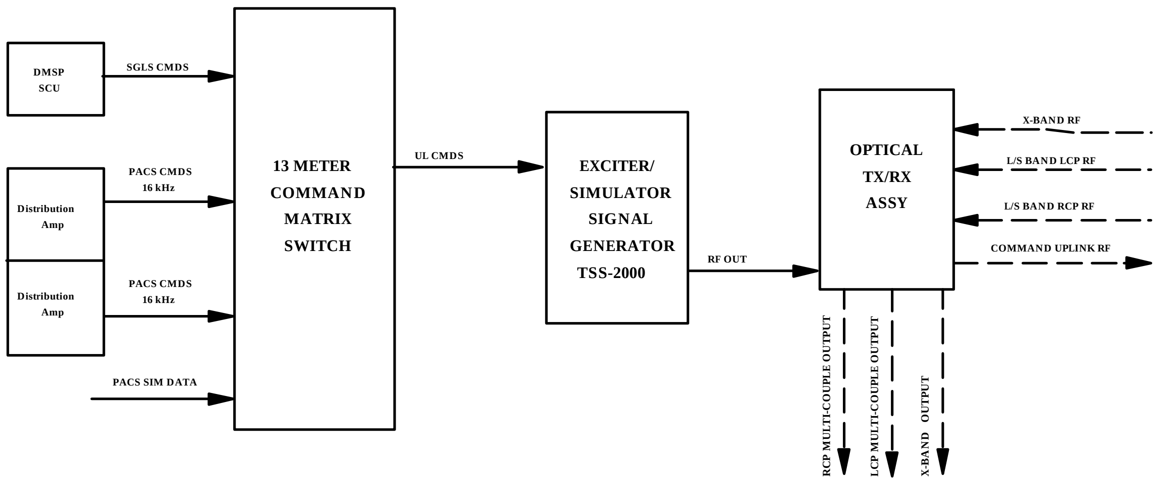

Figure 3.1.1.3-1 Commanding

3.1.2 Fairbanks VHF Receive Antenna System

The VHF receive antenna at the Fairbanks CDA is a 9 element YAGI mounted on an AZ/EL pedestal. The antenna is capable of receiving VHF (136-138 MHz) RF signals. The interfaces between the antenna and the control room are through metallic cables. Once in the control room, the VHF signals are up converted to L-Band (1.67-1.71 GHz). The up converter provides an output to a LCP combiner and an output to a RCP combiner. The LCP combiner also receives a L/S-Band LCP RF signal and the RCP combiner also receives a L/S-Band RCP RF signal from the 13-meter antenna. The RCP and LCP combiners provide their multi-coupled outputs to the 13-meter antenna RCP/LCP Multi-Coupler Assembly for distribution into the 13-meter RF processing equipment. Figure 3.1.2-1 shows the data flow for the VHF receive antenna.

3.1.3 Wallops 14.2-Meter Antenna

The 14.2-meter antenna at the Wallops CDA is a prime focus parabolic reflector mounted on an X/Y pedestal. The antenna is capable of receiving VHF (136-138 MHz), L-Band (1.544.5 GHz), L-Band (1.670-1.710 GHz) and S-Band (2.200-2.300 GHz) RF signals, and transmitting at S-Band (2.02-2.12 GHz). The L and S-Band receive signals are down converted and the VHF receive signals are up converted to 400-500 MHz at the antenna. All these receive signals are then provided to the Interface Distribution System (IFDS) within the control room. The interfaces between the antenna and the control room are through metallic cables

3.1.3.1 Antenna Control

The auto-track capability for the 14.2-meter antenna is provided by the receiver portion of the receiver/combiner unit. Figure 3.1.3.1-1 shows the equipment configuration of the receivers and Figure 3.1.3.1-2 shows the antenna control functions. The receiver/combiner unit is a three channel monopluse track receiver. Two receivers provide an AGC voltage output signal that is routed to the servo electronics unit. This servo electronics unit sends and receives control/status signals to and from the antenna. The servo electronics unit has the ability to switch from program-track to auto-track based on monitoring the AGC levels received. If the ACG level falls below a minimum reading, the servo electronics unit switches the antenna back to the program-track mode.

The 14.2-meter antenna system's receivers are configured by the PACS software. The PACS system provides control and receives status from the PACS Comm Controllers via specific interface devices. PACS provides control and receives status to and from the frame synchronizers, bit synchronizers, receiver/combiners, Metrum Switch and Metrum Recorders. The Wallops CDA Comm Controller is connected to the local TCS and the SOCC TCSs via a LAN. Also tied to the same LAN are the SOCC Comm Controller and the SOMS scheduling function.

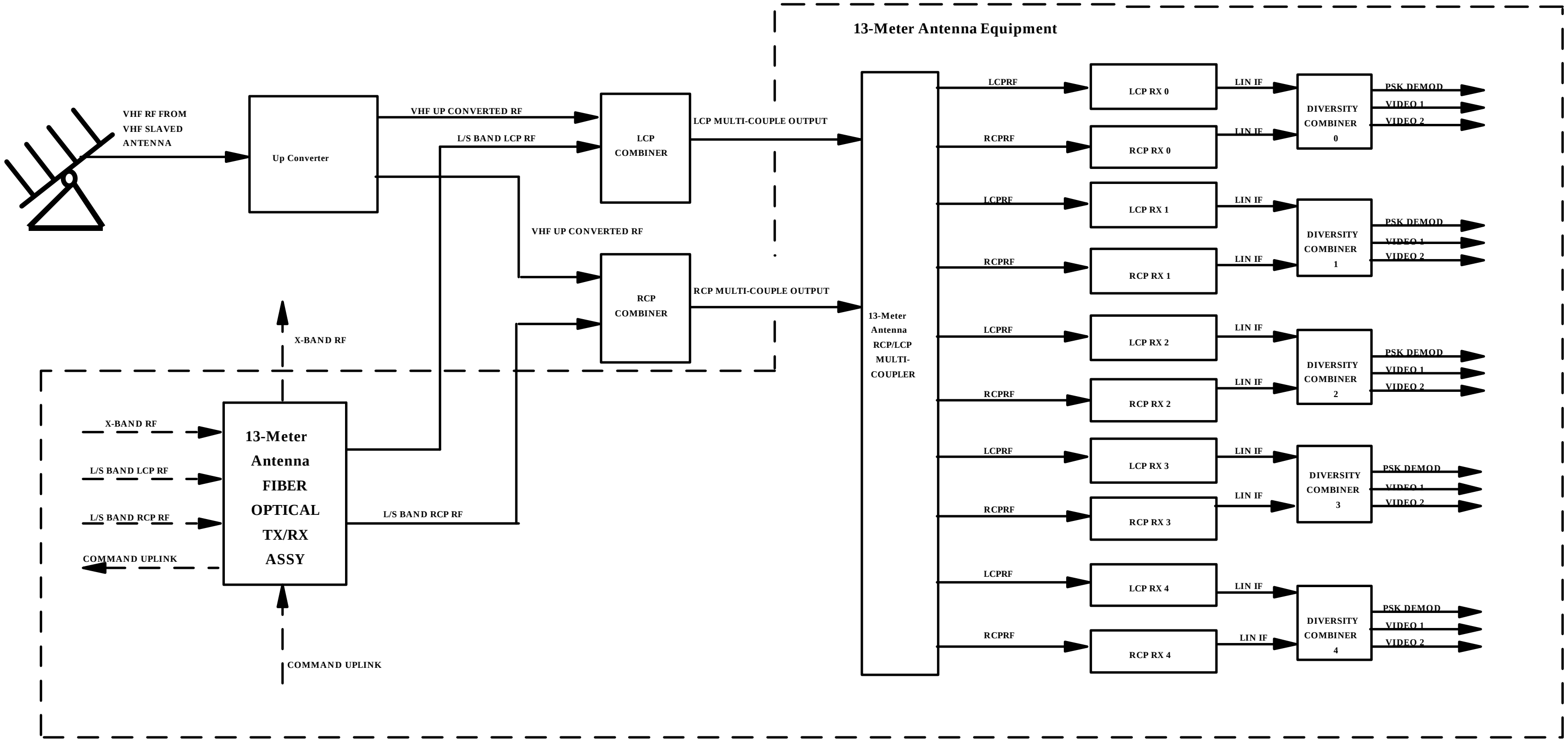

Figure 3.1.2-1 Fairbanks VHF Antenna RF Processing

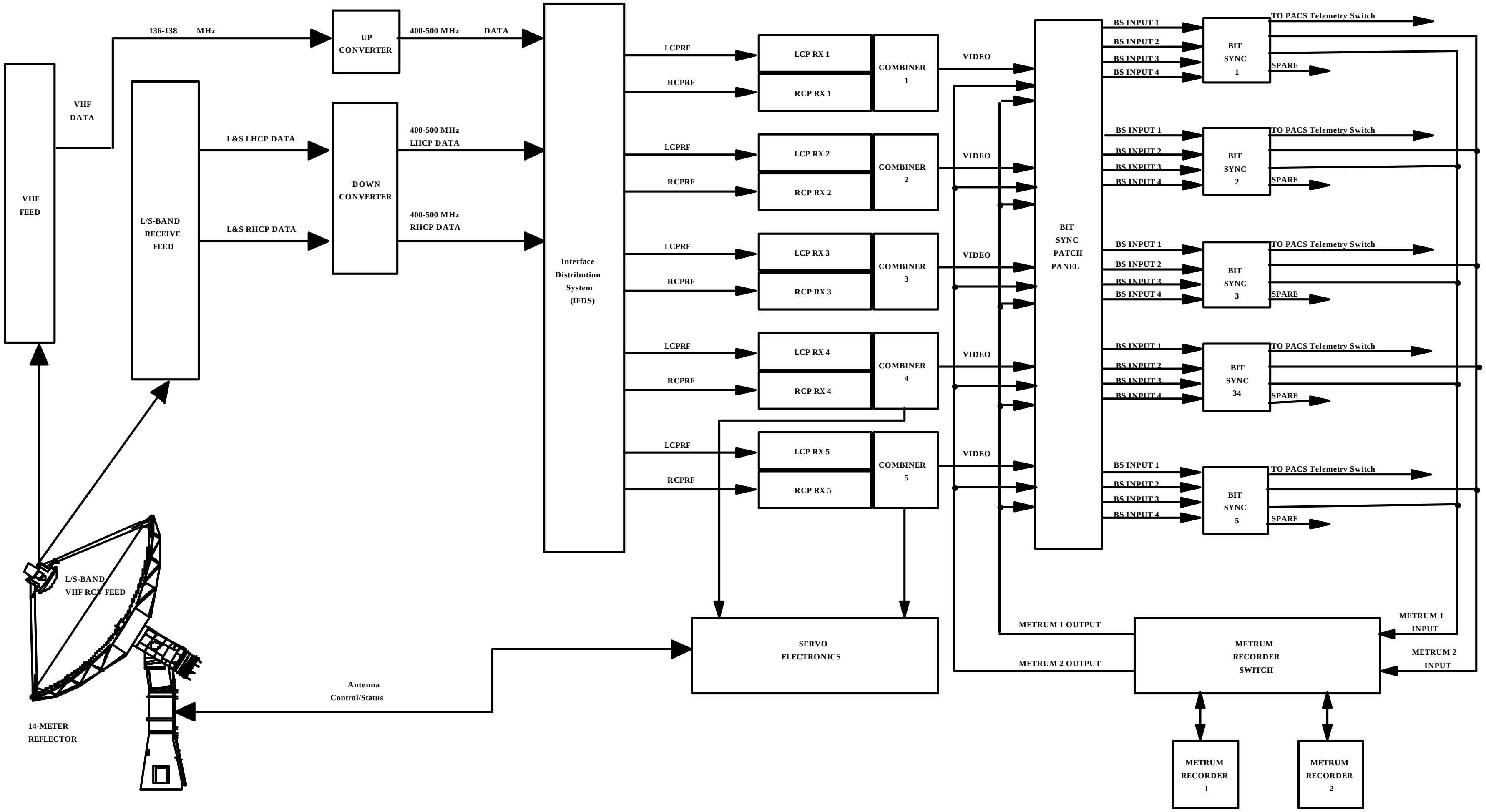

Figure 3.1.3.1-1 Wallops 14.2-Meter Antenna System

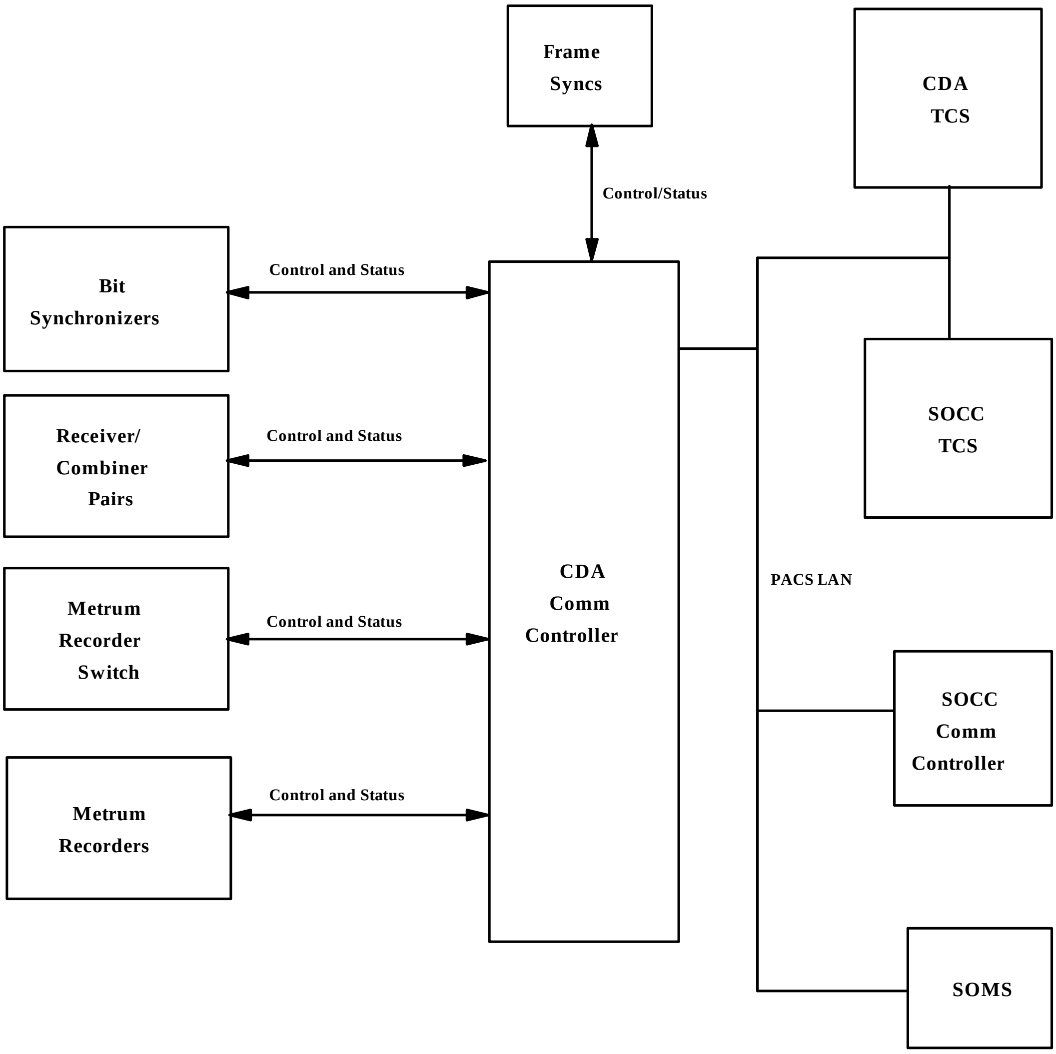

Figure 3.1.3.1-2 Wallops CDA PACS Equipment Control/Status

3.1.3.2 Downlink Data

The downlink data flow is presented in Figure 3.1.3.1-1. The IFDS supplies a left and right hand signal to five receiver/combiners. The five receivers combine the left and right hand downlink signals and provides them to bit synchronizer patch panel. The bit synchronizer patch panel connects the combined receiver output signals to the input of five bit synchronizers. The bit synchronizers provides an output to the PACS Telemetry Switch and two outputs to the Metrum Recorder Switch. There is also a spare output and input. The Metrum Recorder Switch routes the bit synchronizer outputs to two Metrum Recorders.

The Metrum recorders are 14 channel recorders, but two channels are used for servo control leaving 12 channels for record and playback. The two recorders are configured as two independent functions in a primary and redundant configuration. When receiving spacecraft data, the data is recorded on both units simultaneously. During playback, the primary recorder is normally used and the redundant recorder is used in case the primary recorder fails.

The Metrum Recorder Switch selects one of the five bit synchronizer outputs and routes the data to one of the twelve record tracks. The recorders reproduce one track at a time. The playback track is routed by the Metrum Recorder Switch back to the one of the five bit synchronizer's inputs. There is a playback output connection from both recorders to the bit synchronizers via the Metrum Recorder Switch. Record and playback source and destination selections are control by PACS.

3.1.4 Wallops S-band Command Antennas

In addition to the 13-meter antennas at Wallops, a 4 -meter antenna and the transmit portion of the 14.2-meter antenna support S-Band commanding for POES satellites NOAA15, L, M, N, and N'. The transmit range of the 4-meter is 2.024 GHz to 2.110 GHz and the Transmit range of the 14.2-meter is 2.020 GHz to 2.120 GHz. The Command Transmit Equipment located at each antenna includes the High Power Amplifier (HPA), Dummy Load, and Up Converter. Command equipment located within the operations building includes RF Signal Generators and a Signal Combiner.

The RF Signal Generators receive 2kbps commands modulated on a 16 kHz subcarrier and provide 70 MHz uplink RF signals to the Signal Combiner. The combiner is used as a switch to allow either RF Signal Generator to be connected to either the 4-meter or the 14.2-meter Command Transmit Equipment. The Up Converter within the Command Transmit Equipment changes the uplink frequency from 70 MHz to 2.026 GHz and forwards this new frequency to the HPA. The HPA increases the RF power and forwards the signal to the antenna for transmission. Figure 3.14-1 shows the command uplink flow.

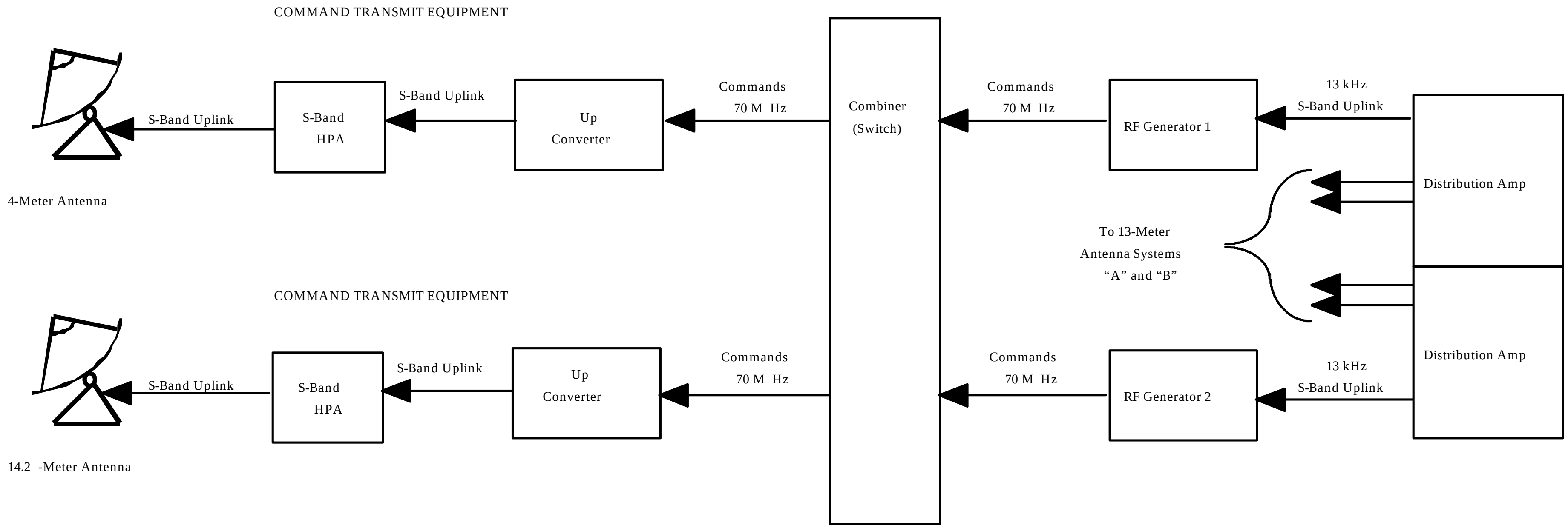

Figure 3.1.4-1 Wallops S-Band Command Antennas

3.2 Downlink Data Routing

The five bit synchronizers from each of the three 13-meter antenna systems at Fairbanks provides data to the POES Telemetry Matrix Switch and to the DMSP Telemetry Matrix Switch. Refer to Figure 3.2-1. At Wallops five bit synchronizers from each of the two 13-meter antenna systems and the 14-meter antenna provides data to the POES Telemetry Switch. Refer to Figure 3.2-2.

The POES Telemetry Matrix Switch routes data and clock from a selected bit synchronizer (1 of 15) to a selected Polar Frame Synchronizer (PFS) (1 of 8). The PFS performs frame synchronization and develops data quality statistics on ingested data. The PFS sends data to the CDA Telemetry and Command System (TCS) via a Comm Controller for further processing. During HRPT ingest, the TIP data and AVHRR data sync deltas are sent from the Communications Controller to the TCS via a low rate interface. During GAC ingest, TIP data is ingested by the TCS via a high rate interface. The POES Telemetry Matrix Switch also routes data from a selected bit synchronizer to the 1.33 Mbps Domsat circuit that forwards the wideband data to SOCC. POES transmits HRPT data to SOCC in real-time, with post pass playbacks of GAC, LAC , SAIP, or STIP data. POES 1.33 Mbps data can also be sent to SOCC from Fairbanks via the DMSP SCU. Connectivity is currently possible at the Fairbanks CDA, but DMSP DOMSAT connectivity at SOCC to the POES SCUs is not available.

The low rate framed synchronized data is ingested into the CDA TCS computer via a Comm Controller. The same data that is provided to the CDA Comm Controller is also forwarded to SOCC in real-time via the 256 kbps narrowband Wide Area Network (WAN) circuit. Spacecraft health and status is monitored in real-time at both the CDA station and SOCC via the PACS workstations. TIP data is also imbedded in the HRPT data stream and can be processed at the CDA or SOCC. Refer to section 4.3 for details of the TCS software processing.

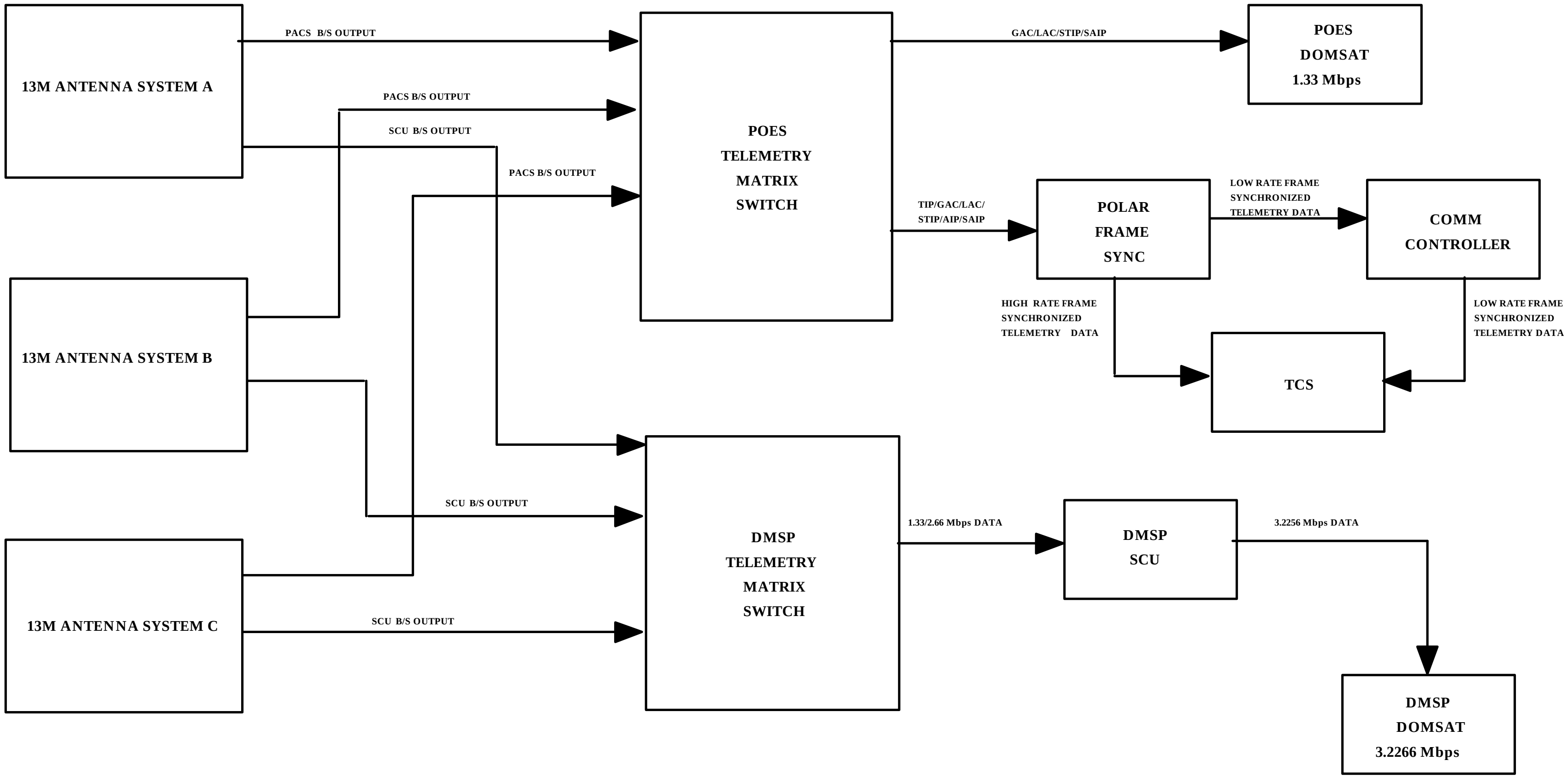

Figure 3.2-1 Fairbanks CDA Receive Data Routing

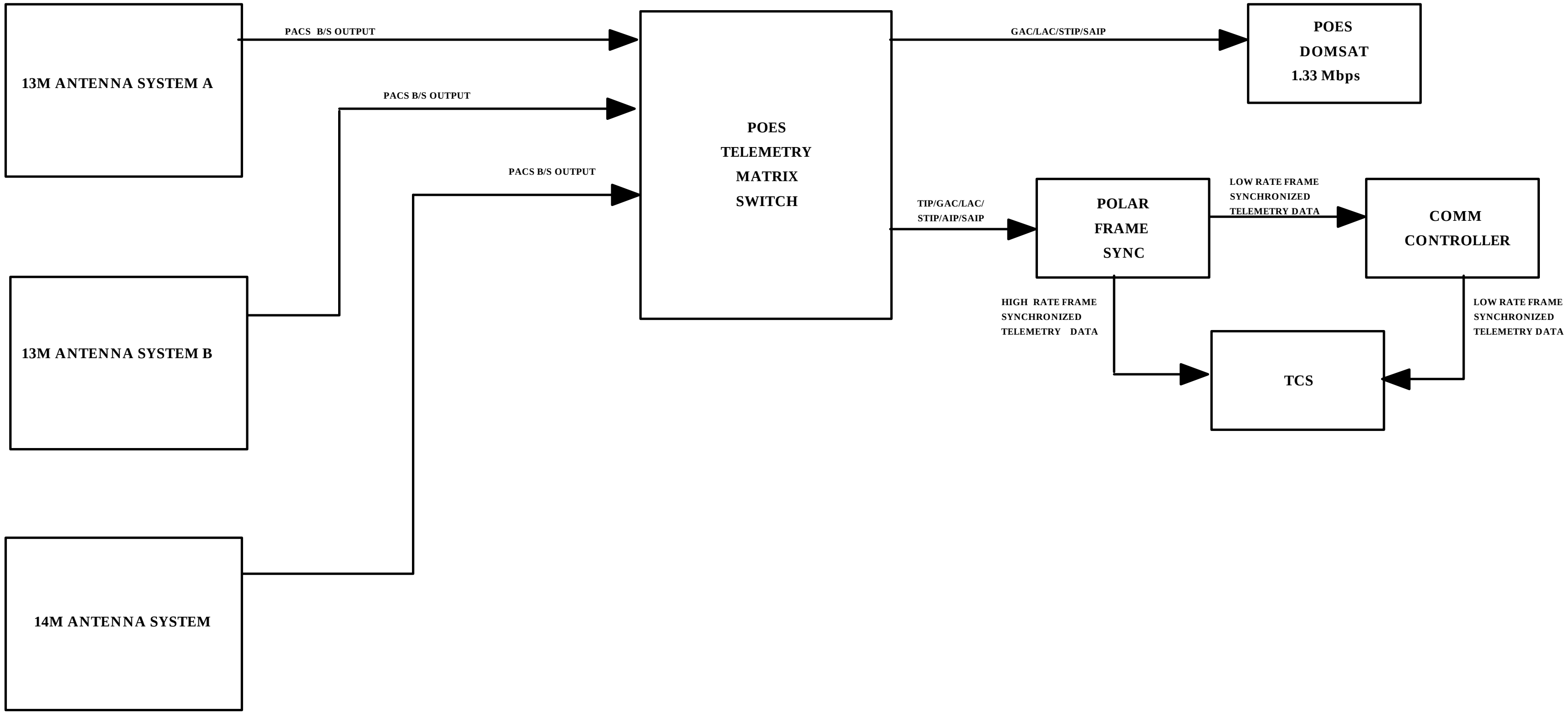

Figure 3.2-2 Wallops CDA Receive Data Routing

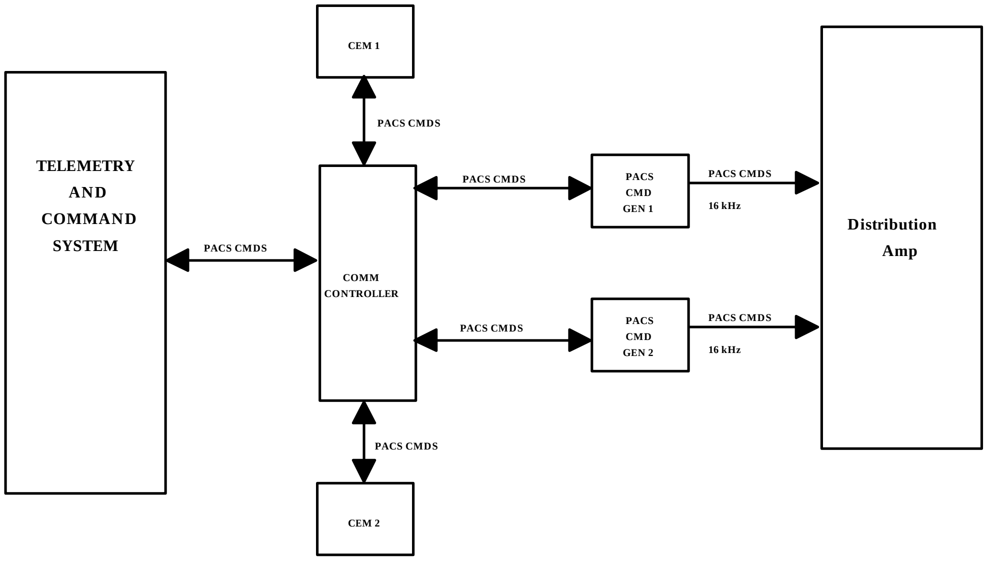

Figure 3.3-1 POES Command Data Flow

3.3 Command Processing

The TCS builds spacecraft commands and sends them to the Comm Controller for transfer to the Command Encryption Module (CEM) and/or the Command Generator. Commands that are to be encrypted before transmission to the satellite, are first sent from the Comm Controller to the CEM and then to the Command Generator. Plain text commands are sent directly from the Comm Controller to the Command Generator. The Command Generator Phase Shift Key (PSK) modulates the commands onto a 16 kHz subcarrier for S-Band uplink. Refer to Figure 3.3-1.

3.4 Personnel Resources

The CDA stations are staffed to support the current requirements of the NOAA polar orbiting missions in an automated environment. However, additional spacecraft support may lead to an increase in the CDA operations staff, depending on the level of effort required to meet the needs of the mission.

3.4.1 Fairbanks Operators

For POES supports at Fairbanks there are three individuals that directly support the satellites. The three individuals are the Operations Leader, Command Telemetry Technician, and the 13-Meter Operations and Maintenance Technician.

The Operations Leader communicates with SOCC, monitors data communications links and equipment configurations, co-ordinates pass requirements, directs personnel, documents pass activities, and monitors preventative maintenance activities. This individual also has equipment maintenance and repair responsibility for 11 racks of equipment .

The Command Telemetry Technician monitors PACS command and schedule execution, manually commands the POES satellite as directed by the SOCC AET, monitors real-time telemetry, assists with data playbacks, monitors data quality, monitors various command equipment and antennas, and prints various documentation such as schedules and anomaly plots. This individual also has equipment maintenance and repair responsibility for 16 racks of equipment.

The 13-Meter Operations and Maintenance Technician communicates with SOCC in accomplishing pre-pass, pass, and post-pass activities associated with POES satellites. This individual insures IMUX tapes are loaded and ready, monitors equipment and data during the pass and is prepared to support the mission in the absence of SOCC due to communication outages or other events. This individual has maintenance responsibility for five racks of equipment. A single 13-meter operator can control all three antennas from a single EPOCH terminal. The 13-meter antennas can also be controlled by PACS and DMSP operators at the SOCC.

3.4.2 Wallops Operators

For POES supports at Wallops there are four individuals that directly support the satellites. The four individuals are the Spacecraft Controller, Telemetry and Command Technician, Antenna Controller and RF Systems Technician.

The Spacecraft Controller communicates with SOCC, monitor data links and configurations, co-ordinate pass activities and keep SOCC and other Wallops operators aware of the progress of the satellite pass. This position also has responsibility to recognize and circumvent real-time failures during a track. They have the maintenance responsibility of one of four major system areas and perform all corrective and preventative maintenance in their area.

The Telemetry and Command Technician monitors TCS command and schedule activities, performs configuration/control of command hardware, monitors telemetry and assists the Spacecraft Controller in pass activities. This person also has a maintenance responsibility of one of four major systems.

The Antenna Controller is responsible for the positioning of the antennas for mission support and configures the antenna systems as needed to support the scheduled passes. This person also has a maintenance responsibility of one of four major systems.

The Systems Technician is responsible for the configuration of all RF equipment required for a given satellite pass, monitor RF lock status and spectrums, and change configurations as necessary to insure maximum data success during a satellite pass. This person also has a maintenance responsibility of one of four major systems.

4 SOCC Description

SOCC, from where all polar ground segment activities are directed, is located on the second floor of Federal Building 4 (FB-4) at Suitland, MD. Within the confines are the SOCC Operations area, SOCC Equipment Room, and Launch Control Rooms. Adjacent to the SOCC are Scheduler offices where polar system schedules are produced.

At SOCC, the PACS uses three DEC VAX 4000 computers in a VAXcluster. These computers, designated Telemetry and Command Subsystem (TCS 1-3), serve as the central computing facility for SOCC operations. They perform the real-time functions of telemetry processing including decommutation, limit sensing, trend data generation, and telemetry history archiving. The TCS performs command generation and formatting in response to Spacecraft Controller workstation keyboard requests. The TCS also performs textual and graphics display generation for distribution through an Ethernet network to VAXStation 3100 workstations and associated printing devices.

The TCS computers also support the non-real-time functions of reports generation, Scheduling, Navigation, Trends plotting and analysis, and the Test and Training Subsystem (TTS) spacecraft simulator.

4.1 Data Routing

4.1.1 Wideband Data

Wideband data is received at SOCC from both the Fairbanks, Alaska CDA (FCDA) and the from the Wallops, Virginia CDA (WCDA) via Domsat satellites. The wideband data flow is shown in Figure 4.1.1-1 and described in the following paragraph. The FCDA transmits two wideband data streams to SOCC. One is a DMSP 3.2256 Mbps data stream and the other is a POES 1.33 Mbps data stream. The WCDA transmits one 1.33 Mbps POES wideband data stream. The FCDA 3.2256 Mbps data stream is provided to the Domsat modem by the SCU switch. The 3.2256 Mbps data stream is transmitted directly to SOCC via a Domsat satellite. Currently there is no connection from the output of theDMSP Domsat modem at SOCC to the input of the two SCUs. The 2.66/1.33 Mbps output of the SCUs are connected to distribution amplifiers. The distribution amplifiers each deliver three separate outputs to the PACS Frame Synchronizer Patch Panel. The patch panel provides the wideband input to the PACS frame synchronizers.

The other wideband link from the FCDA is a 1.33 Mbps data stream. The PACS telemetry switch provides the data to the Domsat modem. The data stream is received by a Domsat satellite and downlinked to GSFC. The same wideband data is immediately uplinked to a different Domsat satellite, which provides SOCC with the FCDA 1.33 Mbps wideband data. The 1.33 Mbps data stream is presented to a distribution amplifier via the Fairbanks Domsat modem. The output of the distribution amplifier supplies three outputs to the PACS frame synchronizers.

The WCDA transmits a 1.33 Mbps data stream from the PACS telemetry switch over a single Domsat satellite. The 1.33 Mbps data stream is presented to a distribution amplifier via the

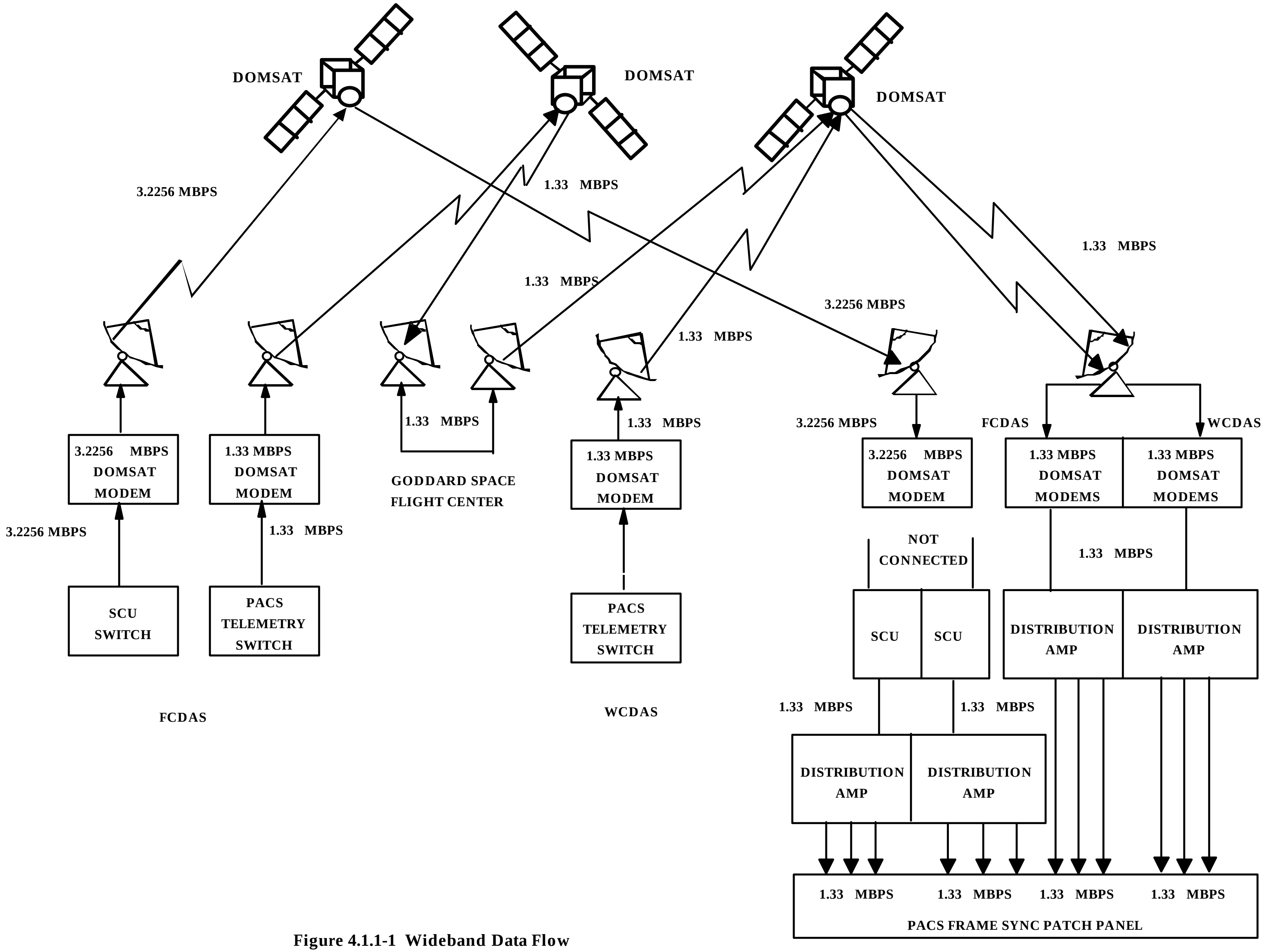

Figure 4.1.1-1 Wideband Data Flow

Wallops Domsat modem. The output of the distribution amplifier supplies three outputs to the PACS frame synchronizers.

The PACS Domsat modems/distribution amplifiers provide wideband data connections to the three PACS frame synchronizers. The frame synchronizers provide three separate data output types. The low (real-time telemetry data) and high data (stored telemetry data) rates are supplied to PACS and the DPSS data (mission data) is supplied to CEMSCS.

Figure 4.1.1-2 shows the low rate data port flow. The real-time telemetry is sent to both Comm Controllers from each frame synchronizer’s low rate data port. The two low rate outputs provide 19.2 kbps RS-422 synchronous interfaces to the Comm Controllers. The low rate port consists of the following data types: Orbit-mode TIP (8.32 kbps), Boost-mode TIP (16.64 kbps), AIP (16.64 kbps), and the TIP/AMSU data embedded in the HRPT data. The output of the Comm Controllers connects to the TCSs. The frame synchronizers receive data from both CDAs. In addition to the low rate data, data quality information is provided over the same data port.

Figure 4.1.1-3 shows the high rate data port flow. The back-orbit telemetry (stored data) is sent to the TCS via the frame synchronizer’s high rate data port. There are four high rate outputs providing interfaces to the TCS computers (only three are used). Each frame synchronizer's high rate output can be connected to any or all of the SOCC TCSs. The TIP and/or AMSU data contained within GAC, LAC, STIP and SAIP are provided over the high rate interface. As with the low rate data, the TCS selects the frame synchronizer’s input source. Data quality information is also sent over the high rate port.

The frame synchronizers also provide two separate DPSS data outputs (mission data) to CEMSCS. Figure 4.1.1-4 shows the frame synchronizer’s interface to CEMSCS. These DPSS outputs are normally dedicated to a CDA and are provided via serial/parallel tri-state differential links. The data types supported by the DPSS are as follows: HRPT, GAC, LAC, STIP and SAIP. Data quality and status information is included in the DPSS output.

4.1.2 Narrowband

The Narrowband communications in and out of SOCC are shown in Figure 4.1.2-1. There are Narrowband circuits for commanding, telemetry, ground system control, satellite engineering support, ground system engineering support and testing. All of these circuit types are discussed in the following paragraphs.

During normal operating conditions, the SOCC operators control the PACS system from a schedule that runs on a SOCC TCS. The CDA operators monitor the schedule execution via a CDA TCS running a schedule identical to SOCC’s. This mode of operation allows either CDA to assume schedule execution if the SOCC is unable to complete the mission. This connection between the SOCC and both CDAs is via the Federal Telecommunication System (FTS) 2000 leased circuits. This circuit is a 256 kbps full-duplex link. This link connects SOCC’s DEC Hub with the DEC Hubs at both CDAs. This 256 kbps circuit allows the following data traffic: specific equipment directives (PACS component set up), spacecraft commands and loads, schedule updates (synchronizes SOCC and CDA schedules), real-time telemetry (low rate),

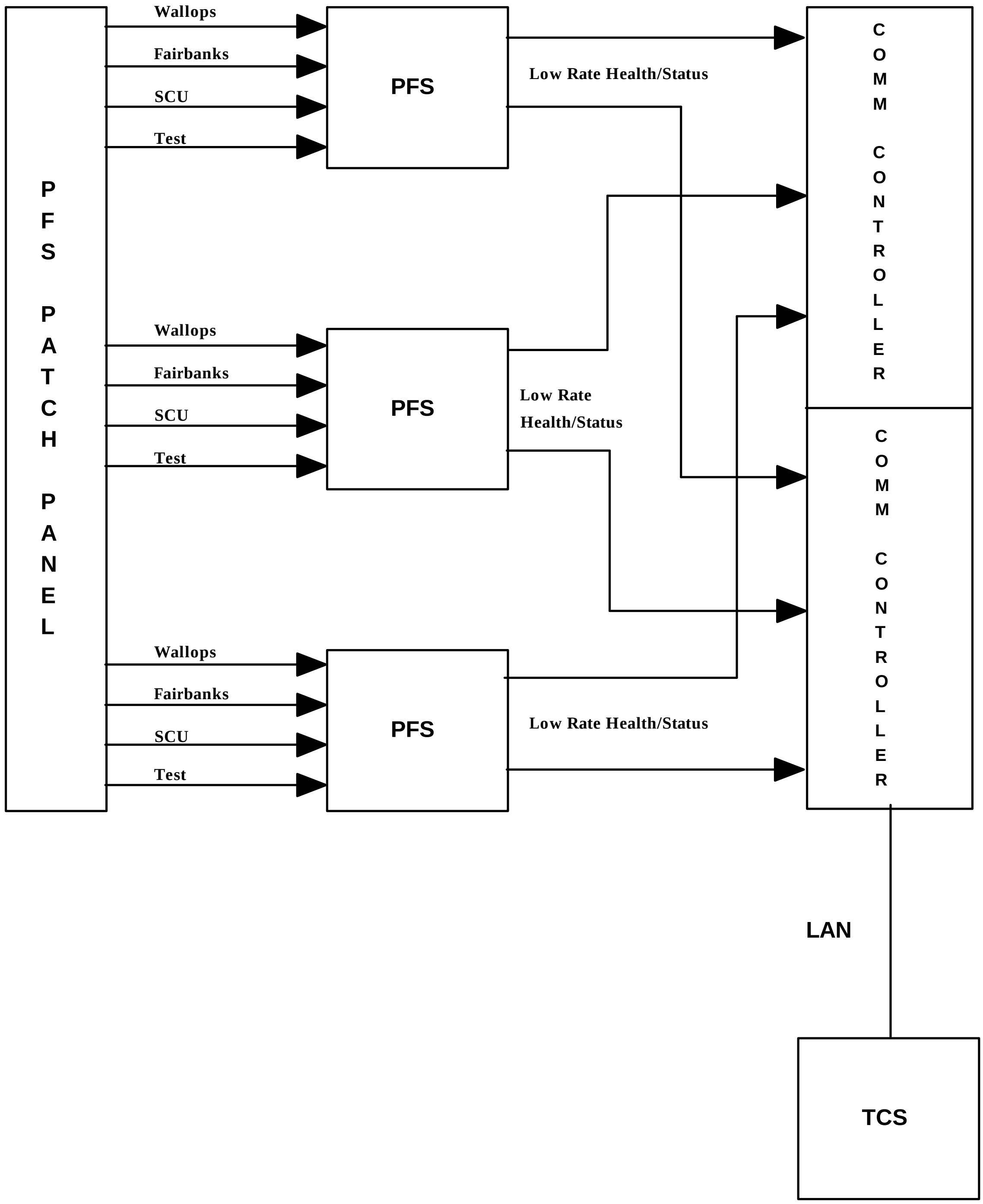

Figure 4.1.1-2 Low Rate Health and Status Data Flow

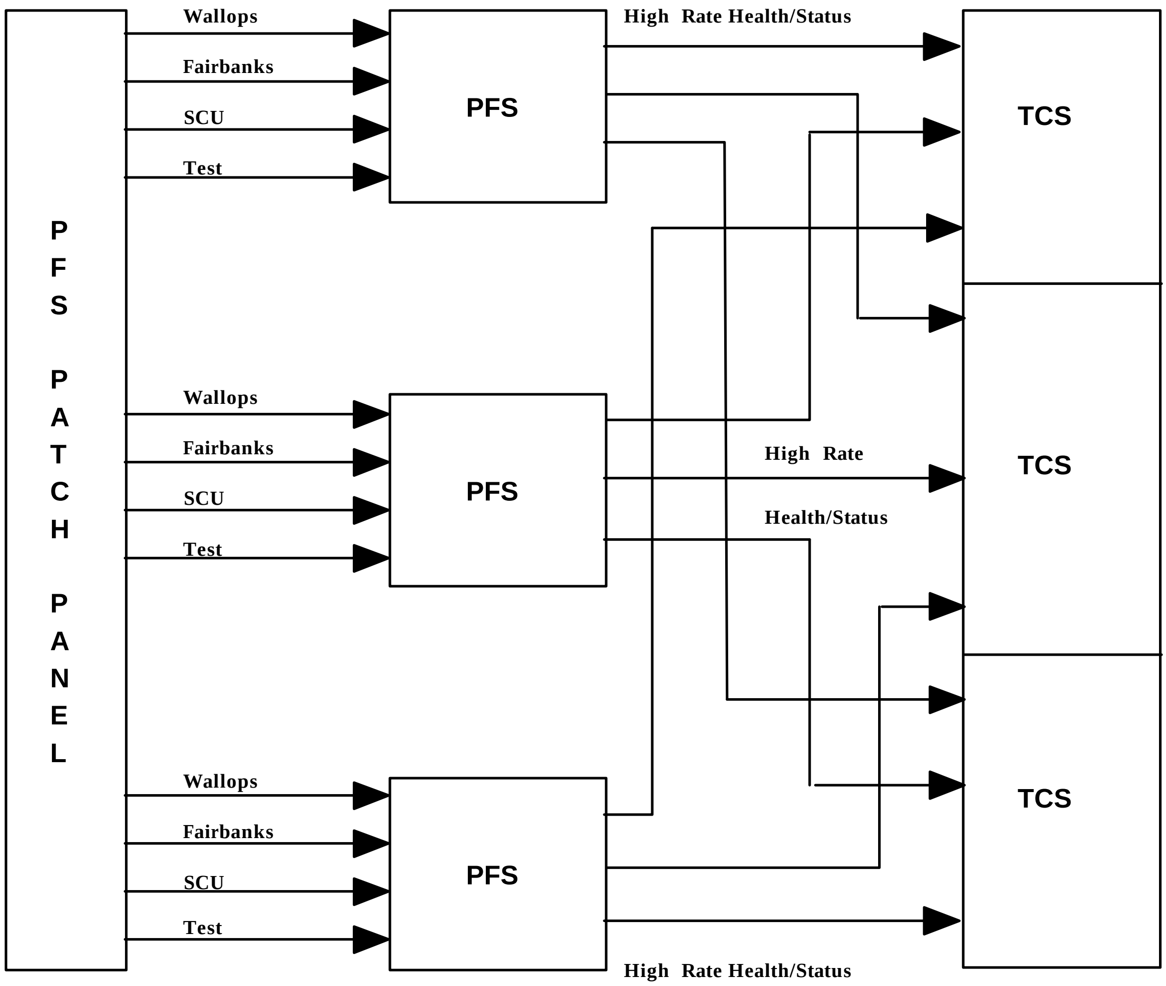

Figure 4.1.1-3 High Rate Health and Status Data Flow

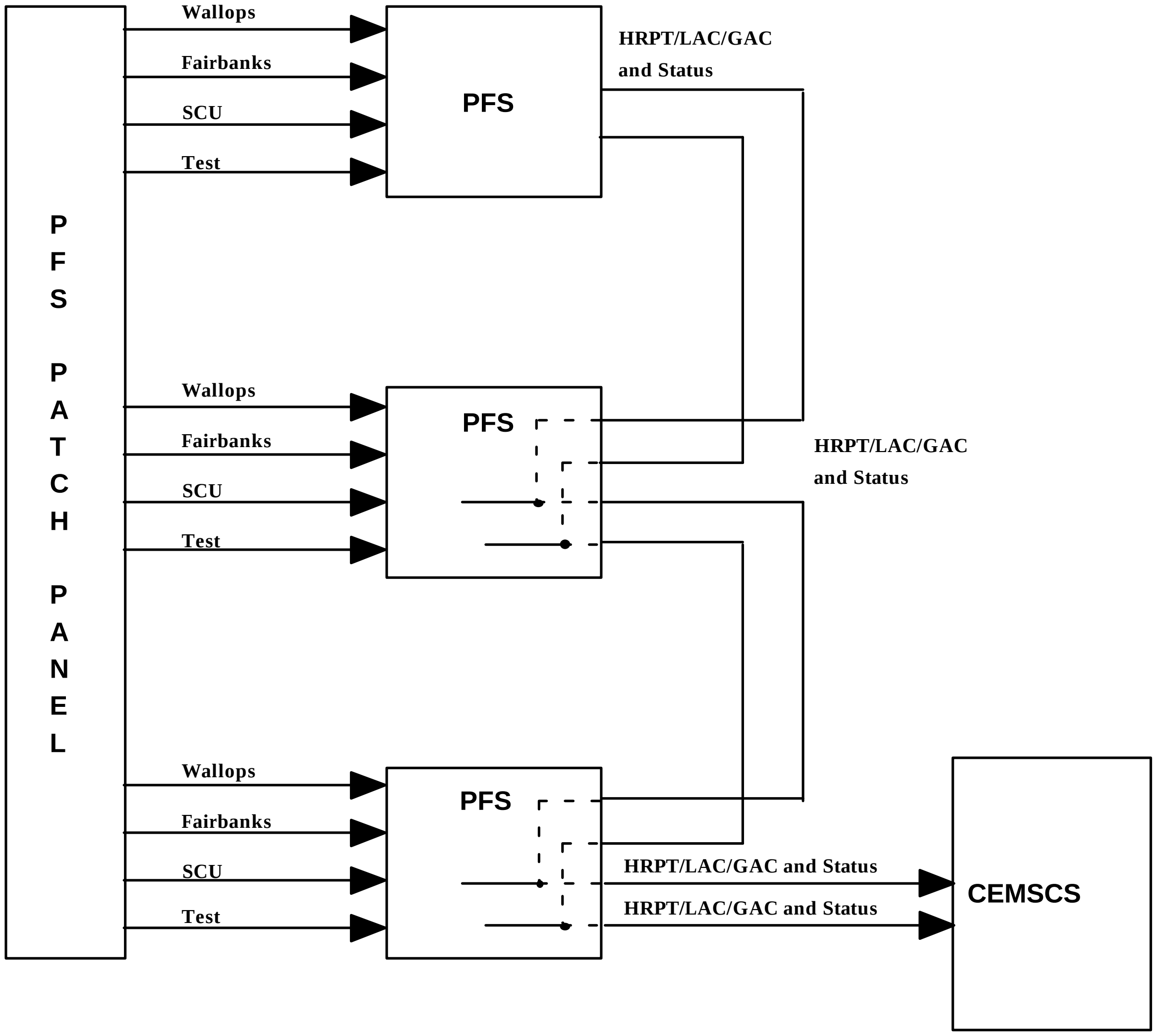

Figure 4.1.1-4 SOCC/CEMSCS Interface

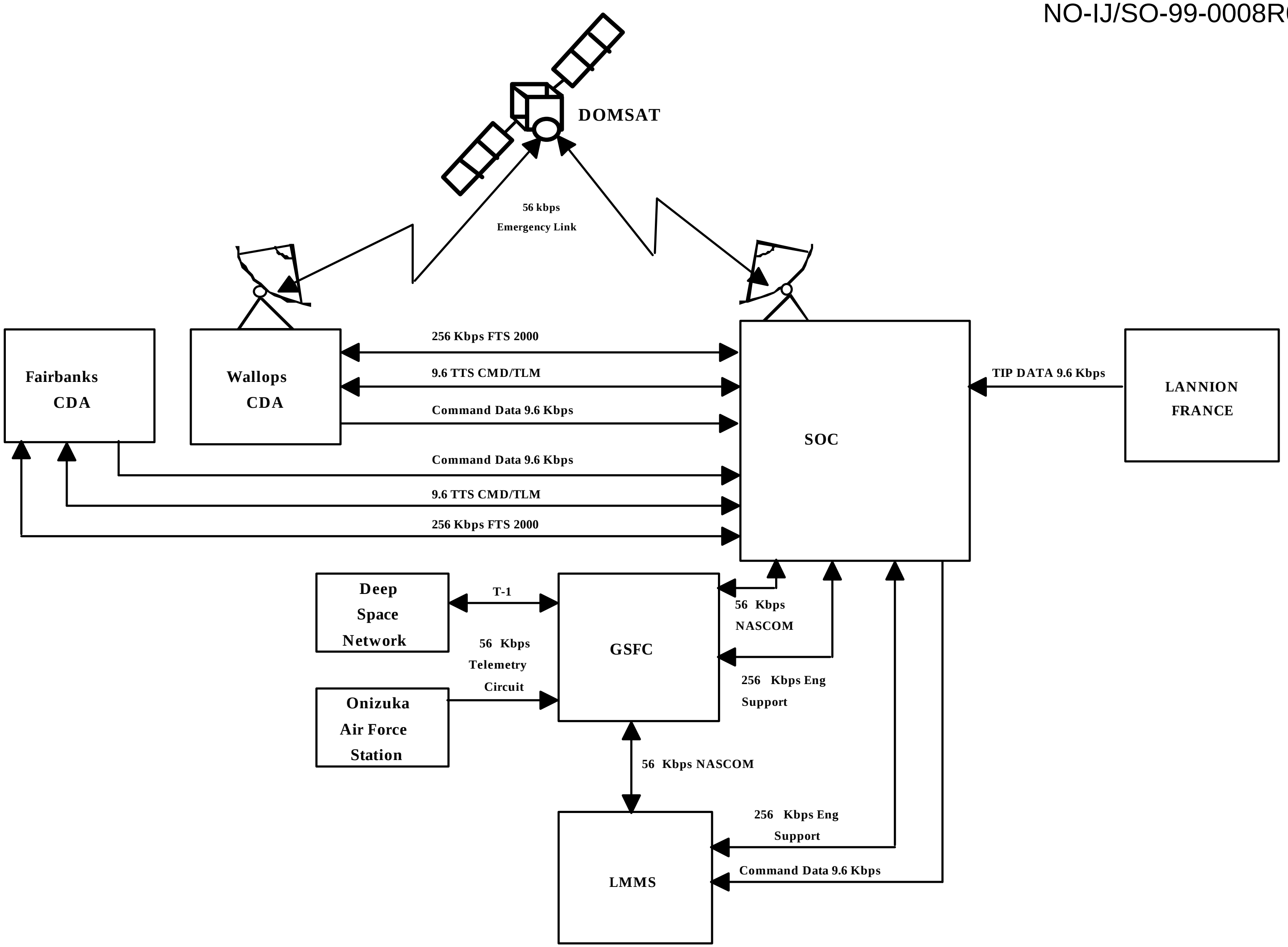

Figure 4.1.2-1 Narrowband Data Flow

data quality and status data. A backup to the FTS 2000 circuit exists. It is a 56 kbps emergency link between SOCC and the Wallops CDA. Connectivity for this emergency link is via Domsat. The same data traffic can be provided on this emergency link as on the FTS 2000 circuit. SOCC also receives low rate data from Lannion, France. Lannion removes TIP data from HRPT data and transmits the framed synchronized TIP data to SOCC over a 9.6 kbps circuit.

During launch and early orbit, the SOCC uses the National Aeronautics and Space Administration (NASA) Communications Network (NASCOM) 56 kbps link to the Goddard Space Flight Center (GSFC). GSFC establishes connections to the Deep Space Network (DSN) stations for commanding and telemetry. GSFC can also establish connections to the Air Force Remote Tracking Stations (RTS) via Onizuka Air Station. This circuit only provides telemetry reception via a 56 Kbps data circuit. Commands are generated on the SOCC TCS and forwarded to the SOCC Comm Controller where they are formatted into 4.8 kbit NASCOM blocks. These NASCOM data blocks are provided to the Small Computer Device (SCD) and converted to IP address format. The IP formatted data is sent over the 56 kbps link to GSFC. GSFC then sends the commands to a DSN station for uplink to the spacecraft. Telemetry is received at DSN or RTS station and forwarded to SOCC where it is provided to the Comm Controller.

There are other narrowband circuit connections used for testing and engineering support. Both CDAs have a 9.6 Kbps circuit, which is multiplexed with the FTS 2000 circuit. This 9.6 Kbps circuit provides connectivity from the CDAs to the SOCC’s TTS.

Both CDAs have an additional 9.6 kbps circuit to SOCC. Either CDA's 9.6 kbps circuit is patchable to a 9.6 kbps circuit between SOCC and the Lockheed Martin Missile and Space (LMMS) contractor support and test facility in Sunnyvale, CA. This 9.6 kbps circuit is used to allow the CDA to send commands to a spacecraft simulator at SOCC or LMMS, or the spacecraft at LMMS during testing. The circuits between the CDAs and SOCC and between SOCC and LMMS allow data transfer in one direction only. Telemetry is returned to SOCC from LMMS through the NASCOM circuits.

SOCC has two 256 kbps data circuits that can be used to support connection to remote PACS workstations. One circuit connects to a workstation at GSFC and the other circuit connects to a workstation at the LMMS contractor support and test facility in Sunnyvale, CA. These remote PACS workstations can be used for spacecraft engineering support.

4.2 Equipment Control

Ground system commands destined for the SOCC and CDA originate from either the SOCC schedule or from the local workstations. The SOCC TCS sends the ground system commands to the primary SOCC Comm Controller via the ethernet LAN. Ground system commands for configuring the CDA are sent to the CDA Comm Controllers via the narrowband channel. The primary Comm Controller at SOCC and at the CDA routes the equipment command to the individual SOCC or CDA piece of equipment. Commands for the 13-meter antenna system are sent from the CDA Comm Controller to the LEO-T workstation. The LEO-T workstation then controls the 13-meter antenna equipment.

4.3 Data Processing

4.3.1 Telemetry Processing Function

At SOCC, the telemetry processing functions are distributed across the TCS, the Comm Controller, and the telemetry archive. Real-time and back-orbit telemetry are ingested in the TCS directly or via the Comm Controller depending on the data type. The frame synchronized real-time telemetry is available from the CDA's Comm Controller via the narrowband link. Real-time TIP data via the NASCOM or Lannion channels is directly input into the SOCC Comm Controller. Real-time telemetry data embedded within HRPT data is available over the Domsat circuit as an input to the SOCC Frame Synchronizer. Refer to Figure 4.3.1-1. The data source selection is under operator or schedule control.

The SOCC Comm Controller receives the low-rate real-time data from the SOCC Frame Synchronizer. The Comm Controller validates the frame, and formats it into packets for transfer to the SOCC TCS. The CDA Comm Controller provides the data to the SOCC TCS via the 256 kbps narrowband link.

In the SOCC TCS, the telemetry data is processed as specified in an associated database for the particular data type and spacecraft. Telemetry processing functions included in the SOCC TCS are 1) on-line history archiving, 2) decommutation, 3) EU conversion, 4) limit checking, 5) pseudo-telemetry generation, and 6) trends processing and archiving. The processed telemetry is made available to the operator workstations over the Ethernet link.

Back-orbit telemetry is received at the SOCC Frame Synchronizer during a GAC, LAC, STIP, or SAIP playback. Back-orbit telemetry is extracted from these data types by the Frame Synchronizer and supplied to the TCS via the high-rate interface.

The telemetry from NASCOM is ingested at the SOCC Comm Controller where the data is unblocked and frame synchronized before it is validated and put into packets for transmission to the SOCC TCS. The NACSOM frame synchronization function is embedded in the Comm Controller software.

The telemetry functions at the CDA are similar to the telemetry functions performed at the SOCC. The front-end processing is identical. The difference is that the CDA maintains a smaller history file and the CDA does not receive telemetry over a NASCOM link nor from Lannion.

4.3.2 Command Processing Functions

PACS is controlled by the daily schedule under normal operations. The command processing functions at SOCC are distributed across the SOCC TCS and Satellite Controller workstations. The spacecraft command schedule generation takes place in the SOMS. SOMS generates the daily schedules and satellite loads, and transfers them to the TCSs at SOCC. The output of SOMS is also downloaded to the CDA TCS over the narrowband communications link so that both TCSs are running/monitoring from the same schedule.

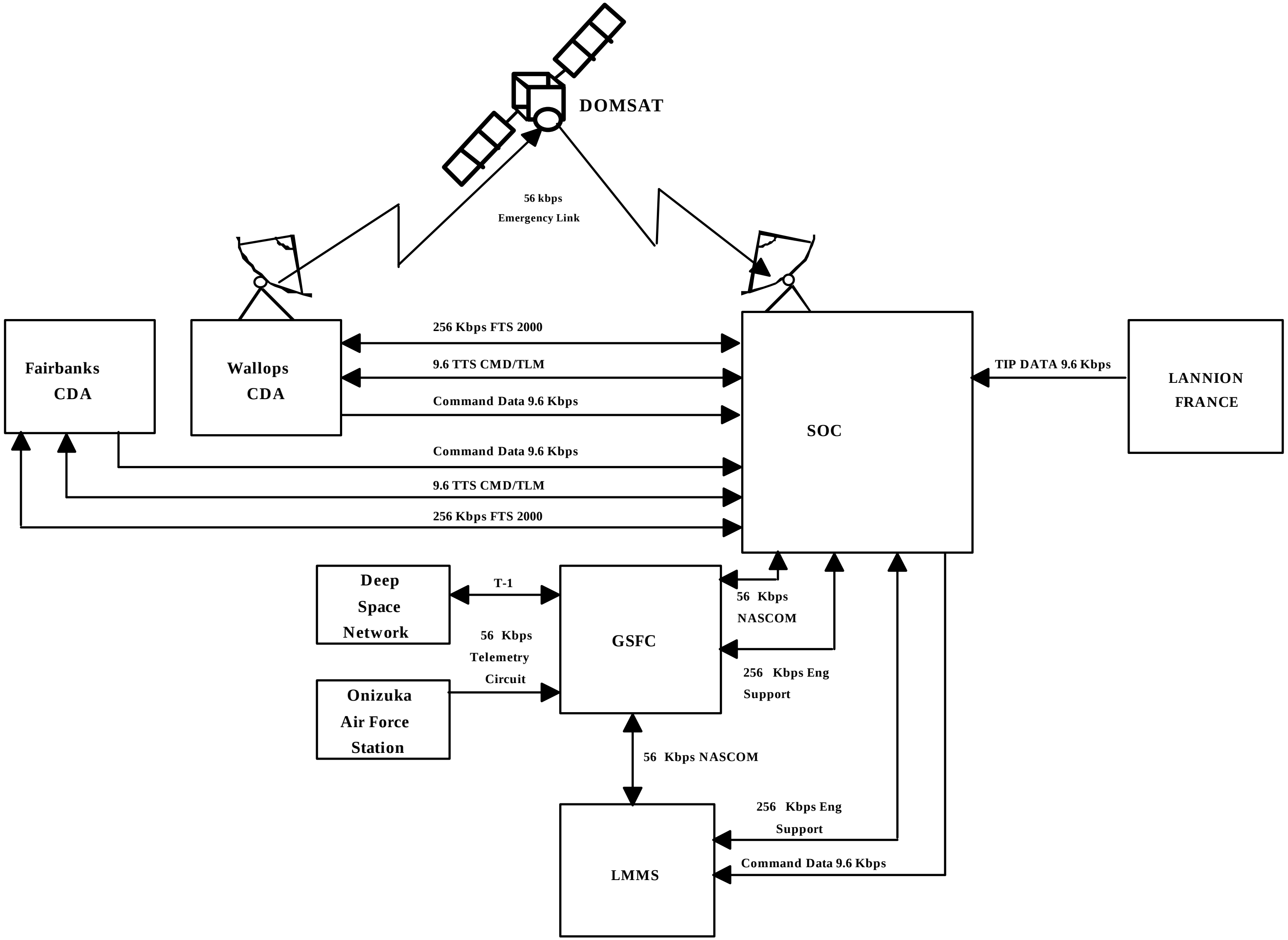

Figure 4.1.2-1 Narrowband Data Flow

Spacecraft commands originate from either the SOCC schedule or from the local workstations. The SOCC TCS sends the spacecraft commands to the primary CDA Comm Controller via the narrowband channel. The primary Comm Controller at the CDA receives the spacecraft commands from the SOCC TCS (or CDA TCS if used as backup), performs the final command processing, and sends the commands to the appropriate PACS equipment (CEM and/or Command Generator).

Spacecraft commands are verified by four methods: syntax check by the TCS on the operator input at the workstation, command verification, telemetry verification, and probe verification. The command and telemetry verification are performed using the telemetry data from the spacecraft. The command verification process looks for the proper status returned in the TIP Command Verification data. The telemetry verification process looks for changes in the values of a given telemetry parameter. Probe verification is when the uplinked command is sampled at the transmitter output and compared to the expected bit pattern. Command and telemetry verification takes place in the TCS while probe verification is accomplished in the Command Generator.

4.3.3 Non-Real-Time Processing

The PACS NRT subsystem includes all of the offline processes and functions required to support the POES satellites which are not directly related to the real time satellite pass. The NRT processes includes1) telemetry, command, and display page databases: 2) telemetry history and trends processing, 3) system reports, and 4) scheduling..

The telemetry database contains the information needed by the real-time telemetry process to convert the raw satellite telemetry counts into engineering units. The command database contains a list of valid satellite commands, the format to transmit them, and any pre-requisite states of the satellite prior to execution of the command. The display page data base consists of a description of all of the operator display pages within the system.

All of the ingested telemetry, direct read out and satellite back-orbit data, is stored in segment files. These segment files are further processed and stored in a history archive file. This data may be used in either analysis reports or played back as an input to the real-time telemetry processing software. Trending is performed on certain data parameters and then stored.

PACS has the ability to generate a series of reports that allows operations to know how the system is functioning. These reports 1) compare the amount of expected data frames to the actual data frames received, and 2) provide a detailed history of all events that occurred during a given time frame.

4.4 Scheduling

SOMS is the PACS scheduling system that provides the full capability to schedule both the ground equipment and the POES satellite missions. SOMS provides three levels of scheduling, contact level, event level, and command level.

Contact level scheduling provides the satellite contacts that will be taken at each CDA based on the POES satellite orbits. SOMS determines possible conflicts between POES satellites and schedules those satellites by priority at the respective CDA.

Using the rules that have been placed on the operation, SOMS determines the events that can take place during each satellite orbit. This includes how much data can be recorded on the satellite and downlinked at the selected CDA sites and what command uplinks can occur.

SOMS then builds the satellite onboard command table and the ground system commands that will be used to control both the satellite and the ground system.

De-confliction of the 13-meter antennas at Fairbanks is initiated in SOMS. SOMS schedules the POES satellite passes needed at the Fairbanks and Wallops CDAs. POES schedulers perform de-confliction between POES satellites at the Fairbanks and Wallops CDAs. The POES contact level schedule is then generated by SOMS and sent to the DMSP Mission Planning and Scheduling System (MPSS). MPSS uses the SOMS contact level schedule to determine when the Fairbanks CDA is available for DMSP use. MPSS then schedules the necessary DMSP passes at Fairbanks. Note that POES has priority over DMSP since POES passes are scheduled first and DMSP must schedule around the selected POES passes. After MPSS schedules the necessary DMSP satellite passes, a combined schedule is generated and forwarded to the 13-meter LEO-T workstations.

4.5 SOCC Personnel Resources

The SOCC is staffed to support the current requirements of the NOAA polar orbiting missions. For POES support there are three individuals at SOCC that directly support the satellites in real-time. The three individuals perform the Aerospace Engineering Technician (AET) function, Fairbanks Controller function, and the Wallops Controller function. A single AET operator can monitor two POES satellite passes. Each controller is under direct supervision of the AET.

The AET monitors the status of spacecraft subsystems from received telemetry data and provides real-time engineering evaluation and operational assessment of spacecraft and ground system operations. As the senior technician on duty, the AET validates PACS schedules, command programs, orbital tracking data and operation instructions. The individual is responsible for real-time engineering evaluation and operational assessment of orbital tracking data and operational instructions, provides input into simulation plans and launch procedures and participates in their execution, and maintains continuity of data from team to team.

The Fairbanks and Wallops Controllers directs the execution of scheduled operations in accordance with control center guidelines, executes all required spacecraft control actions; configures the PACS ground system and monitors its performance; controls ingest, distribution and processing of spacecraft schedules; assists support personnel in executing operations as directed; advises AET of changes to normal satellite states; assists in operating new systems; conducts simulator training when directed; reviews new control center documentation; reviews and files control center spacecraft data file printouts; coordinates data transfers between remote sites and users; conducts data flows; and facilitates communication links with remote sites.

5 Backup SOCC

The PACS ground system provides operations with the capability to fail over from the SOCC to the CDA during critical time periods when the SOCC can not successfully perform its mission. The Wallops and Fairbanks CDAs have the capability to provide command transmissions and data acquisition to and from the spacecraft. During short-term SOCC outages, the SOCC is backed up by both CDAs. If the failure is long-term, the Wallops CDA is the preferred backup station. This is primarily due to the relative closeness of the Wallops CDA compared to Fairbanks CDA. The short-term and long-term backup scenarios are discussed in the following two paragraphs.

5.1 Short-term Backup

During normal operations, the SOCC TCS is the commanding TCS and its Command Schedule is the one that is controlling the ground equipment and sending the commands to the spacecraft. The CDA normally runs the same schedule as the SOCC. This PACS operational capability is known as the Schedule Synchronization mode. In this mode, the CDAs Command Schedule shadows the execution of the Command Schedule at the SOCC. If the TCS at the SOCC fails, the CDA operators can enter a few directives and assume complete control of the spacecraft. Under short-term backup conditions there would be no scheduling, trending or history archiving functions performed at the CDA.

The CDA can assume commanding control by changing the mode of operation from Synchronized to Normal. This directive will suspend the Command Schedule as well as put the CDA into a local commanding mode. Next the CDA must take command authority for the spacecraft from the SOCC TCS. This will result in the CDA TCS becoming the commanding TCS for the spacecraft. The final step is to resume the schedule execution. This action allows the execution of the Command Schedule from the point at which it was suspended to switch control sites. Control is transferred back to the SOCC by returning the mode of operation to Synchronized at the CDA and by taking command authority and resuming schedule execution at SOCC.

5.2 Long-term Backup

If SOCC operations are suspended for longer than 24 hours, the Wallops CDA becomes the operational SOCC. The actions required for the Wallops CDA to assume local commanding and control are the same as in paragraph 5.1. There would be additional functions and resources required at the Wallops CDA for it to fully assume the responsibilities of SOCC. These additional functions are scheduling, trending, engineering and history archiving. Scheduling personnel as well as analysts, spacecraft engineers and crew members would temporarily relocate or commute to the Wallops CDA to conduct the mission activities normally associated with SOCC.

When Wallops CDA is in the long-term SOCC backup mode, there are communications changes that can be made to allow the Fairbanks CDA to backup the Wallops CDA. The communications vendor for the FTS 2000 circuit must be notified to reconfigure data circuits to provide direct connection between the CDAs. Once the communications reconfiguration is complete, the Fairbanks CDA can be configured to run in the Synchronization mode. In this mode, the Wallops CDA will receive status from the Fairbanks CDA and Fairbanks can backup Wallops.

5.3 Personnel Resources

The Wallops CDA would need to be staffed to support the NOAA polar orbiting missions for long term backup. Three individuals will be needed per 12 hour shift at Wallops to directly support the satellite operations. They will perform the AET function, Fairbanks Controller function, and the Wallops Controller function. A single AET operator will monitor two POES satellite passes. Each controller is under direct supervision of the AET. Additional personnel will be needed to perform the satellite engineering, software maintenance, and scheduling functions.

6 Acronym List

AET	Aerospace Engineering Technician
AGC	Automatic Gain Control
CDA	Command and Data Acquisition
CEM	Command Encryption Module
CEMSCS	Central Environmental Satellite Computer Center
CPU	Central Processing Unit's
DEU	Digital Electronics Unit
DMSP	Defense Meteorological Satellite Program
DPSS	Data Processing and Services Subsystem (old name for CEMSCS)
DSN	Deep Space Network
FCDA	Fairbanks Command and Data Acquisition Station
FEP	Front End Processor
FSK	Frequency Shift Keying
FTS	Federal Telecommunication System
GSFC	Goddard Space Flight Center
HPA	High Power Anplifier
IFDS	Intermediate Frequency Distribution System
IMUX	Intelligent Multiplexer
LAN	Local Area Network
LCP	Left-hand Circular Polarization
LMMS	Lockheed Martin Missile and Space
MPSS	Mission Planning and Scheduling Subsystem
NASA	National Aeronautics and Space Administration
NASCOM	NASA Communications Network

NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanographic and Atmospheric Administration
PACS	Polar Acquisition and Control Subsystem
PFS	Polar Frame Synchronizer
POES	Polar-orbiting Operational Environmental Satellite
PSK	Phase Shift Keying
RCP	Right-hand Circular Polarization
RF	Radio Frequency
RTS	Remote Tracking Stations
SCD	Small Computer Device
SCT	Stored Command Table
SCU	System Communications Unit
SGLS	Space-Ground Link Subsystem
SOCC	Satellite Operations Control Center
SOMS	Satellite Operations Management Subsystem
TCS	Telemetry and Command Subsystem
TIROS	Television Infrared Observation Satellite
TUTR	Tunable Universal Tracking Receiver
TTS	Test and Training Subsystem
WAN	Wide Area Network
WCDA	Wallops Command and Data Acquisition Station